Technorama

FOR PROFESSIONAL ENGINEERS AND DECISION MAKERS

ENGINEERING FOR A HEALTHY PLANET

The Institution of Engineers (India)

Qatar Chapter

Editor's Note

Dear Engineers
It is an endeavor of Institution of Engineers India Qatar Chapter to release the Technorama Magazine as part of Centenary Celebration of The Institution of Engineers India headquartered in Kolkata India conducted on 26th and 27th September 2019 in Doha at Qatar University Campus. It was a first ever overseas event of the Institution held in jointly with Qatar University and Qatar Foundation-Research, Development and Innovation (QFRDI) as Technology Partner and College of North Atlantic Qatar as Knowledge Partner.

The Centenary International Engineering Congress was held on the 26th September 2019 with panel discussions and technical seminars on the theme "Smart Engineering – state of the art technologies in oil & gas .and Infrastructure development. The conference discussed different advanced and state of the art technologies and technological innovations of integrated engineering processes for development of oil and gas, petrochemical and civil infrastructure by eminent Engineers from different parts of India and Middle East Engineering fraternity which includes academia and professionals from various field.

Technorama comprised all the articles presented in Technical Seminars in the best possible manner and hope all of you enjoy and benefit for the Technical enhancement .

Best Regards

Er.Salihudeen.KM. FIE

Nation building using Performance-Based Durability Design of Marine Infrastructure for 120 years

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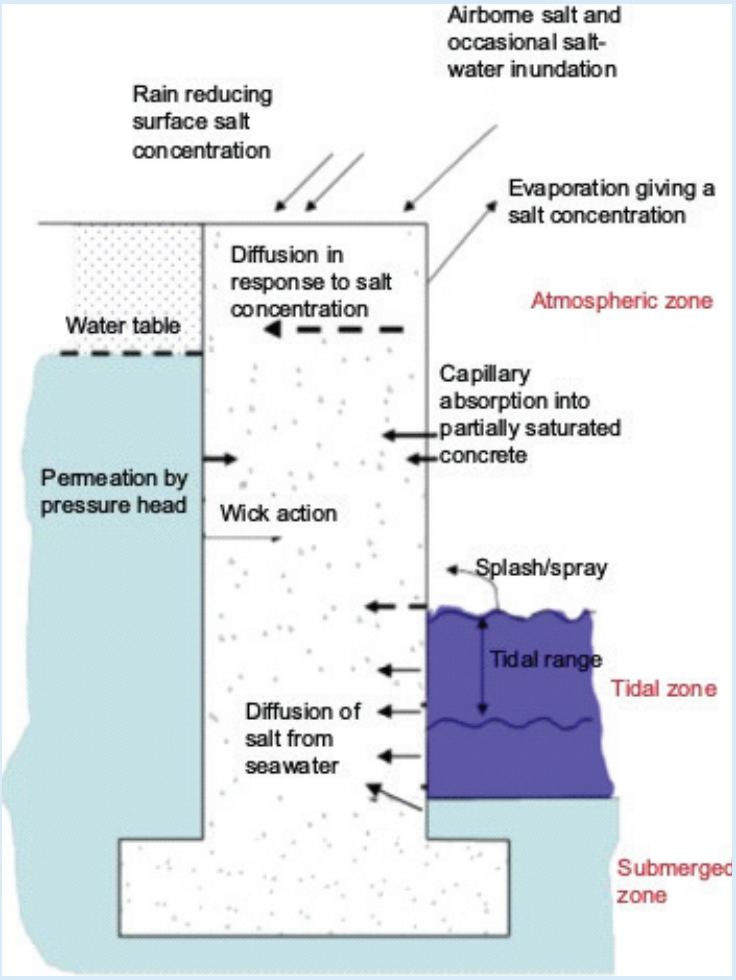
Abstract - This article proposes the methodology for durability design of marine reinforced concrete infrastructures which suffers reduced life due to steel reinforcement corrosion. A change of design approach is recommended, from the conventional "prescriptive/deemed-to-satisfy approach" practised by current design standards to a "performance-based approach" which considers the actual ageing process through probabilistic treatment. A full-probabilistic model-based durability design is performed on the achieved performance against the chloride ingress, serving as basis for a "major" maintenance free life. Using the model for chloride ingress and specified durability limit state, the design parameters are evaluated in terms of service-life of 120 years and target reliability level. During the course of 120 years, rise in temperature due to global warming will be significant, which accelerates corrosion. In this paper global warming is incorporated in the performance design. The design is demonstrated using a case study of a marine quay wall of a typical harbour. This article is based on the authors experience in providing durability design for infrastructures.

MOTIVATION

The demand for human development worldwide continues to grow, and much of this development is occurring in the marine areas because of the great advantages of coastal localities in terms of trade and transport opportunities, areas suitable for human habitation, recreation and accessibility. The current global population is approximately 7.3 billion, of which approximately 44% is estimated to live within 150 km of the sea [1].

Our country India has close to 7500 km of coast line. An example demonstrating the importance of coastal infrastructure is the Sagarmala programme initiated by the Government of India (GOI). The mission of this programme is to invest close to Rs. 4 lakh crores (Rs. 4 trillion) [2] in modernising the existing marine infrastructure. Such huge investment demands that the built facility be maintenance free and attain its intended service-life, since the return on this investment is justified by the service-life attained and the life cycle cost.

Reinforced Concrete (RC) is widely used in the marine environment, and in its various forms permits the construction of coastal facilities, including docks and harbours, quays, jetties, wharves, seawalls, pipelines, tunnels, and so on, which in turn facilitate onshore and near-shore developments. It is also a popular choice for infrastructure of coastal cities, such as bridges, residential structures, warehouses and administrative institutions. Concrete will continue to be the construction material of choice for use in marine environments, as well as in a range of other demanding environments, into the foreseeable future. At this stage, there is simply no other viable alternative [3].



Chloride induced corrosion of reinforcement steel is the leading cause of deterioration of reinforced concrete structures in marine environment [4], reducing the service-life of such infrastructures. The annual cost of corrosion in India is 3% to 4% of the Gross Domestic Product (GDP) [5]. This loss of the nation can be avoided by adopting "performance based durability design" [6, 7] with a specific target service-life which serves to be economically most profitable and adds value to a marine infrastructure project.

CONCRETE DURABILITY

Concrete durability problems arise from the aggressiveness of the environment to which the structure is exposed. Different exposure conditions in the marine environment are shown in Fig. 1. Such exposure promotes chloride induced corrosion of reinforcement steel. The main reason for such durability problems is the interconnected porous nature of the hydrated cement paste.

In the construction industry, durability is expected to be achieved through strength. But there is no simple or unique relationship between strength and any of the durability parameters [9, 10]. For example, a given grade of concrete made with different binders types say pure Ordinary Portland Cement (OPC) or OPC blended with Supplementary Cementitious Material (SCM) will have different durability property (database [11]), but same strength. The key to concrete durability is the achievement of a "designed concrete pore structure". The unique way towards this goal is by specifying the concrete accurately for its intended purpose. The specification should address different aspects such as intended service-life, quantifiable description regarding serviceability requirement and failure, acceptable level of risk and possible extent of maintenance.

A. Conventional durability design

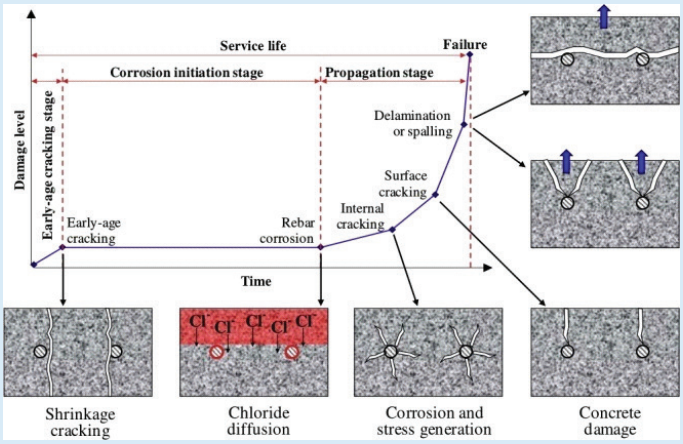
Conventionally, the durability design of a concrete structure for a target working life is achieved using a "prescriptive (deemed-to-satisfy) approach". The prescriptive approach, based on acquired experiences and empirical data, provides the requirements for material composition and structural details for given environmental actions and target working lives.

This approach is followed by most design codes in use

(IS 456:2000 [12], IS 4651:2014-4 [13], IRC 112:2011 [14], IRS CBC:1997 [15]). These provisions include limits of

- Minimum cement content,
- Maximum water cement (w/c) ratio
- Minimum grade of concrete
- Nominal concrete cover

However, the fulfilment of a particular service-life (say 120 years), if all of these prescription are satisfied, cannot be quantified using this approach. In other word, if all requirements are satisfied, what will be the achieved service-life? Further this approach neither quantifies what constitutes the end of service-life. To provide solution to such a question, there is an increasing demand to incorporate more advanced concepts related to concrete durability, due to the need to better foresee and prevent distresses, in particular the corrosion of the reinforcement.



PERFORMANCE BASED DURABILITY DESIGN

The corrosion process in concrete is highly complex with various physical-chemical interactions among saline solutions, solid phases of concrete and moisture. The complicated nature of the process leads to significant uncertainty when modelling corrosion [16]. In addition there is significant uncertainty associated with some of the parameters which dictate corrosion initiation, such as the time dependent diffusion coefficient, the critical chloride content and the provided concrete cover [6, 7]. The presence of such engineering uncertainty necessitates the adoption of "performance-based approach" for design. The performance-based approach involves modelling the real ageing process of structural materials under environmental actions and employs mathematical models to evaluate the required properties and structural dimensions for expected design lives through probabilistic treatments. These methods allow the uncertainty associated with all levels of corrosion process to be incorporated into the analysis, leading to a robust and informed design. The performance-based approach is an 'engineered approach' to durability design.

Considering structural design of durability for corrosion processes, the design factors are, concrete cover quality (diffusivity), concrete cover thickness, and crack control criteria. The concrete cover quality and thickness are designed through the durability models with the target service lives and appropriate Durability Limit States (DLS) adopted. For the performance design procedure, the concrete surface is supposed to be exposed directly to aggressive agents (Cl–). The model-based design follows a reliability analysis format with a target probability of failure, PT and corresponding target reliability level βT [6].

A. Design Life and Durability Limit State

The asset owner desires a working life of 120 years for a particular port concrete facility. Aiming for this target, the durability design should first decide the working lives for each elements on the basis of their structural importance and technical feasibility. The basis being that the principal elements have the same working life as the whole project (120 years), whereas the secondary or replaceable elements can be shorter. For these elements the maintenance and replacement schemes should be specified in the design phase.

DLS are needed for quantitative durability design using the performance-based approach. These are the minimum acceptable performance levels for different durability processes. Fig. 2 shows in principle the performance of a concrete structure

with respect to reinforcement corrosion and related events. The states after corrosion initiation stage calls for a significant maintenance due to concrete cracking and steel loss in terms of replacement of cover concrete, reinforcements and remedial treatment leading to substantial investment in re- pairs. For a 120 years project it is desired that the reinforcement is not depassivated for the desired service-life.
Practically meaning a maintenance free life.

B. Corrosion deterioration model

The design model for chloride-induced corrosion is adapted from the analytical model of diffusion. With the DLS specified as the corrosion initiation state, the design equation is

$$G = Cth - C(Cs, xd, Dc, TSL) \quad (1)$$

The objective being to obtain cover thickness (xd) and specifications of the concrete such as the chloride diffusion coefficient of concrete (Dc) for the specified design life (TSL = 120 years) subject to

$$P(G<0) \leq PT$$

$$\beta T = \Phi^{-1}(PT) \quad (2)$$

.

where, Φ is the cumulative distribution function of the standard normal variable. C(.) is the chloride concentration function in concrete. This model has four governing parameters

- Threshold chloride concentration (Cth)
- Concrete surface chloride concentration (Cs)
- Chloride diffusion coefficient of concrete (Dc)
- Concrete cover thickness (xd)
- The effect of temperature rise due to global warming affects Dc, thereby accelerating the ingress of chlorides.

C. Prima facie design

As a starting point it is suggested to adopt the codal prescriptive durability provisions. These provisions are benchmarked with the performance design and checked if the required service-life is achieved. If the codal requirements are more than sufficient for the required life, they are adopted, else the designed provisions are provided.

The statistical properties of the four model parameters are analysed on the basis of the long-term in-place structural investigations and exposure tests conducted in the vicinity of the proposed project in the past or based on literature. It is advised to identify these parameters and must be included in the feasibility investigation for the project. The investigation comprises of environmental data extracted from site investigation for atmospheric temperature, humidity, and air-borne chloride content and wind speed. Further, the evaluation of chloride pro- files of structures in the vicinity of the proposed project or similar projects elsewhere must be incorporated. This investigation helps to statistically characterise the diffusive property of concrete and evaluate the distribution of surface chloride concentration. Since the concrete cover is the only structural parameter in the design equation, correct specification of concrete cover thickness is the central issue for durability design. The statistical properties of concrete cover thickness are important for correct estimation of reliability with respect to the design equation, and are related closely to the construction methods and practice. Statistical analysis based on the data of achieved cover thickness of similar concrete infrastructures must be investigated or tolerance prescribed by the codes may be used.

CASE STUDY

As requirement for a new concrete harbour, a service-life of 120 years is specified for caisson quay wall (Fig. 3) at Vizag. The part of the caisson facing the tidal zone is most prone to corrosion initiation.

A. Conventional strategy

As per IS 456:2000 [12], the exposure condition can be considered to be "Extreme". The "durability design" for Extreme exposure according to the prescriptive provisions of IS 456:2000 are:

- Minimum nominal cover : 75 mm
- Minimum cement content : 360 kg/m3
- Maximum cement content : 450 kg/m3
- Max w/c ratio : 0.4
- Aggregates : 20 mm nominal maximum aggregate size complying IS 383:2016 [17]
- Min concrete grade : M40
- As highlighted previously, by satisfying all the prescriptive requirements the following important aspects remain unanswered:
- Actual achieved service-life
- How to consider Global Warming effect
- Recommendation on type of cement concrete

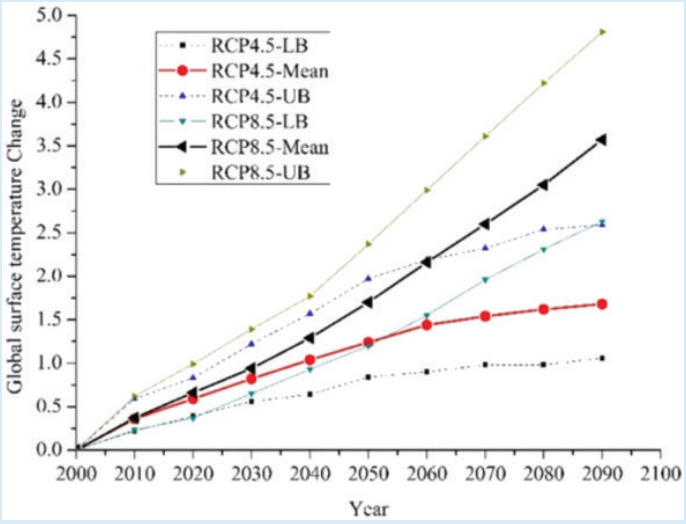
B. Performance based strategy

In this section two tasks will be undertaken:

- The prescriptive durability design will be benchmarked using the performance based design to calculate the actual achieved service-life of these provisions.
- Actual performance calculation will be done to de- sign the caisson for 120 years.

The target reliability level is $\beta T = 1.3$. The governing parameters of the design are probabilistically quantified as follows:

- Chloride load (Cs): A Gaussian chloride surface concentration having mean 5.5 % weight of cement with 1.3 % weight of cement as standard deviation [18].
- Critical chloride (Cth): Critical chloride concentration at reinforcement level for corrosion initiation is 0.6 % weight of cement and 0.15 % weight of cement as standard deviation. This is a Beta distributed variable with limits of 0.2 and 2 % weight of cement [19].
- Chloride diffusion (Dc): For comparison two types of concretes varying only in cement types viz. OPC and OPC+Slag SCM, but same w/c=0.4. The chloride diffusion values are sourced from database [11].



Global warming: At present the average temperature at Vizag is 27.83 'C with a standard deviation of 2.7 'C. Future anthropogenic emissions of greenhouse gases and aerosol particles would cause climate change and temperature rise. In the IPCC Fifth Assessment Report released in 2014 [20], some climate change scenarios were simulated and referred to "Representative Concentration Pathways" (RCPs). In the present project a medium stabilisation scenarios (RCP 4.5) is considered (Fig. 4)

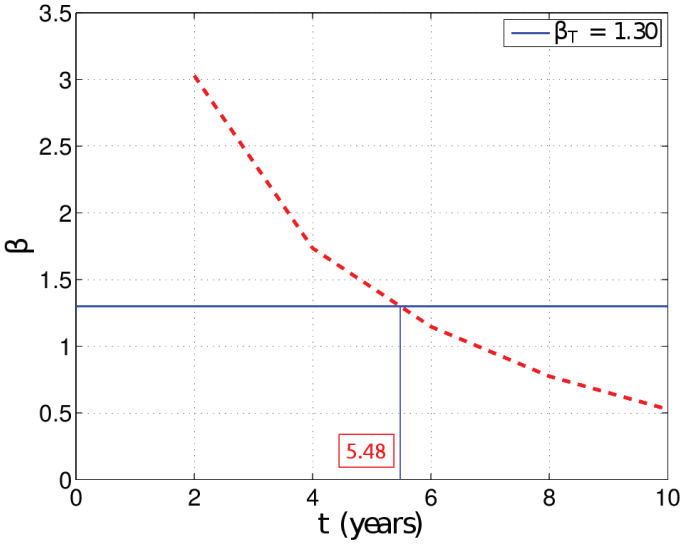
Figure 4: Projected annual average global warming

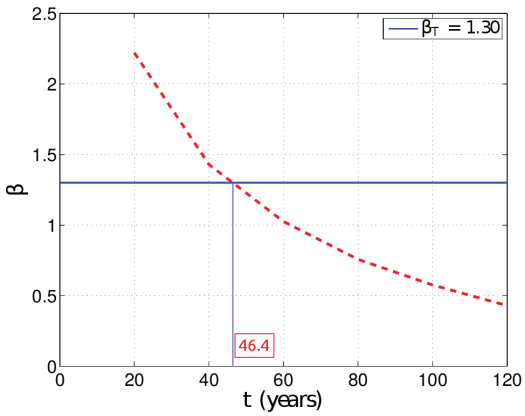
- Clear cover (xc): The concrete cover is 75 mm with standard deviation of 6 mm, which implies execution requirements targeted. This is a Beta distributed variable [19].

C. Results

achieved by using OPC cement and using the conventional approach. The achieved service-life is 5.48 years. This is far from achieving even a life of 10 years let alone achieves a life of 120 years. Fig. 5(b) shows reliability plot and service-life achieved by using OPC+SCM cement and using the conventional

approach. This shows that the achieved life is 46.4 years which is more than the previous analysis but still far from achieving a life of 120 years. This highlights the importance of the "performance based design". Fig. 5(c) shows reliability plot and service-life achieved by using OPC+SCM cement and using the performance based approach. Cover required as per design is 125 mm and the service-life possible is 120.58 years.





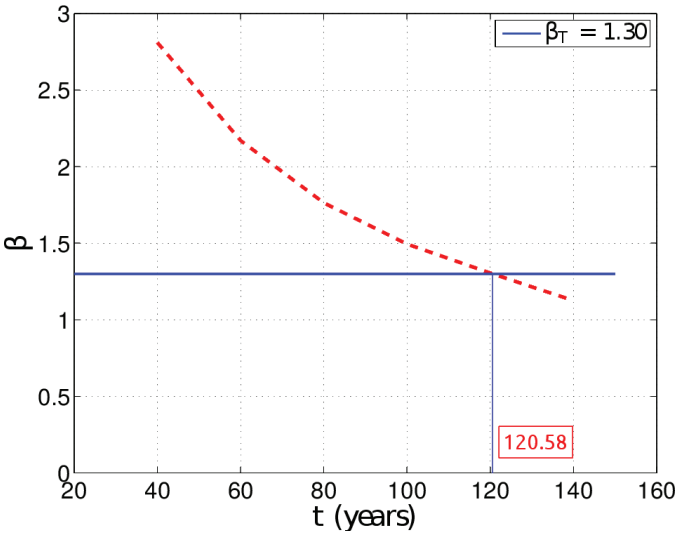


Figure 5: (a) Benchmark of conventional approach with OPC concrete and 75 mm cover; (b) Benchmark of conventional approach with OPC+SCM concrete and 75 mm cover; (c) Performance design for 120 years service-life

D. Impact

The performance approach offers following advantages:

- Quantification of achieved service-life for any design.
- Design modification under non-compliance of actual service-life.
- Incorporates climate change which manifest over the long service-life.
- Design option of selective use of stainless steel, lower w/c concretes and other SCMs is also possible, leading to further reduction of concrete cover and material consumption.
- Can be used as input to the support system for making decisions based on life-cycle cost analysis.
- Allows practically for the non-maintenance of the infrastructure.

DESIGN VERIFICATION

A. Design assisted by testing

Based on the prima facie design, the required construction material and specifications for executing the design can be used as design basis for the project. However, every project is unique and precise characteristic of the de- sign are quantified by testing the material used at project site.

During the construction, the properties of structural concretes should be tested in on-site laboratory. In parallel, the constructed concrete elements, prefabricated or cast-in-place, are inspected for the achieved quality, and particularly for the thickness of concrete over. These data provide the information on the realistic construction quality of concrete elements, thus help to update the statistical properties of parameters in the durability assessment models. The measurements of concrete cover thickness for

the cast-in-place concrete elements are done either through, ground penetrating radar, electromagnetic test, ultrasonic and radiography.

The in-situ data of chloride diffusion coefficient of structural concretes are to be collected from the on- site laboratories for different concrete elements. The chloride diffusion coefficients are measured on structural concretes under standard conditions by rapid migration method [21]. The concrete surface chlorides are tested as per Ref. [22] and airbourne chlorides is obtained following Ref. [23]. The critical threshold chloride concentration is evaluated by the accelerated chloride threshold testing [24]. Additions of admixtures such as ground granulated blast furnace slag, fly ash, silica fume and metakaolin alter the properties of ordinary portland cement concrete. Testing of such concrete is therefore crucial to study its chloride ingress property and statistically characterise it to apply in the performance-based design. This updated data source, form the essential basis for predicting the durability performance of concrete elements during its service-life.

B. Monitoring and Maintenance Planning

The maintenance planning is to establish the techniques and intervention periods of maintenance, on the basis of the durability states of the concrete elements. The strategies of maintenance planning is to be preventive/proactive, which refers to the intervention at early stage of deterioration, normally at low maintenance costs. During the service-life, the deterioration processes will be monitored via periodical inspection and sensors. The maintenance actions are to be taken at early stage of deterioration for elements with the help of these inspections and monitoring. Since concrete elements are designed in such a way that the probability of corrosion initiation (PT) will only be exceeded after 120 years, technically all elements can be exempted from maintenance during the service-life. However, given the uncertainty associated with the concrete construction, e.g. early-age cracking, unintended lower concrete cover, accidental use of saline water for concrete mixing and/or curing and the unexpected environmental actions during the long service-life, e.g. the global warming and long- term change of ambience, a basic maintenance planning is necessary for concrete elements. Through monitoring of as-built concrete components it is possible to establish the service-life of the casted components in real-time.

The basic maintenance planning considers mainly two aspects: the durability performance monitoring, and maintenance of the elements. Monitoring involves: potential mapping, resistivity mapping, embedded anode sensors, cover thickness measurement, air permeability, chloride profile, etc. It is also beneficial to cast test concrete elements near the actual structures so that monitoring can be done on them rather than the actual components. The maintenance scheme consists of performing the surface chloride extraction by electrochemical method or a cathodic protection system can be installed to protect the steel bars against the unexpected durability failure. It should be noted that this basic maintenance scheme is to interact with the durability inspection/monitoring data and the real-time durability assessment during the service-life. A predictive maintenance scheme is setup for the same.

In essence the performance-based approaches is fundamentally a measurement and verification design procedure.

INCLUSION IN TENDER DOCUMENT

In the present scenario, asset owners of coastal ports specify the conventional prescriptive requirements as per code in the design basis report. However, they wish to know how much really is the achieved service-life and what can be done to have a “major” maintenance free life. It is necessary that the change should begin at tendering stage of the project.

The tender document should mandate the requirement to study the durability factors and incorporate in the feasibility exercise, to evaluate all the environmental parameters responsible for degradation,

including review of previous statistics for similar projects elsewhere, for e.g. the Hong Kong-Zhuhia-Macau (HZM) project [25]. This will be the design basis for the preliminary performance-based design. The asset owner must emphasise on specific durability limit state as per their requirement and mention the expected service-life and target probability of failure. Testing of in-situ components along with the number of tests to be performed are necessary part of the design basis. The asset owner must press for the requirement of probabilistic durability design in the tender document with a design report. And finally long term monitoring and updating of actual service-life must be included as part of the contract.

CONCLUSION

There is massive capital investment on coastal infrastructure in our country. To safeguard these investments and avoid costly repairs and renovation due to premature deterioration of RC structures, it is prudent to verify the properties of concrete cover (its penetrability and thickness). This technical article recommends the change of approach to the asset owners/concrete industry from traditional prescriptive approach to the performance-based specifications. It highlights important steps involved in the durability design of concrete components with a case study. It is recommended to bring about a change of approach from the tendering stage itself. The applicability of this technology is universal, both for new infrastructures [6, 7] as well as for repairing the existing assets [26].

DURABILITY DESIGN OF MARINE INFRASTRUCTURE FOR 120 YEARS

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A new methodology in identification of Risk in Engineering phase of Fast-track project

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Abstract - Each project is unique and execution of Fast-track project within the time and budget is quite challenging. The fast-track project possesses various phase which envelope various identical and dissimilar system / package. Each phase in fast-track project are concurrent with other phase. The challenge commences from Engineering phase in each fast-track project which are termed as Risk. Engineering phase is pivotal point that leads downstream phase in the project. It is necessary to identify and assess Risk from inception of the project till handover. The risk involved in Engineering process are inherent in each project due to design complexity, team communication, experience of team member, geographical location etc. In this paper, a new methodology has been proposed to identify the risk by breaking down the Engineering process based on the scope of a project. Concurrently, this break-down methodology supports Planning of the activities along with risk identification. Risk identification should to be precise such that Risk assessment and its mitigation plan should support the project to meet project objective rather than being an ornamental.
Keyword: Fast-track project; Engineering phase; Engineering process break-down; Risk identification; Risk assessment & mitigation plan; meeting project objective.

Introduction

Each project is executed on EPC or turnkey basis. In this paper, the risk identification in the Engineering phase of turnkey project is been analyzed. Engineering phase of every project is a temporal process. In the turnkey project, various system needs to be designed such that Engineering completion of one system will initiate or influence the ongoing stage of another system. Fig.1 shows a broad classification of Engineering process namely Basic Design which holds specification of system/ package to initiate detail engineering and Detail design which influences most of Engineering phase by elaborating the specification to reality. In short, Engineering phase possess various micro stage gate which sum-up to final stage gate of Engineering phase. Delay in Engineering of upstream will have a cascading effect on Engineering progress of downstream which in turn challenges the Project objective.

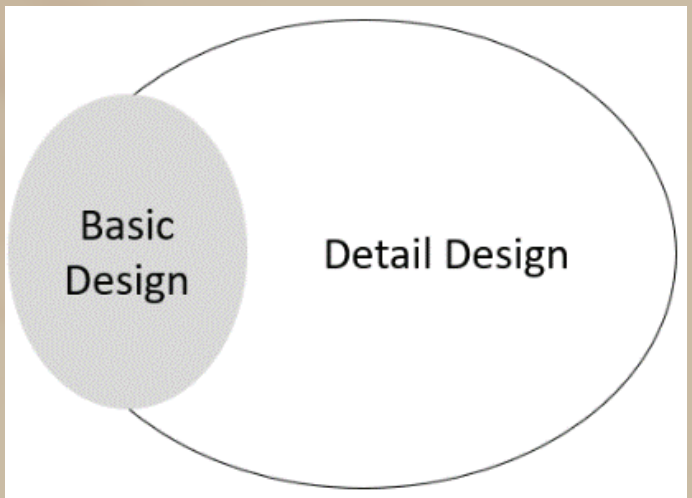


Fig.1 Basic Component of Engineering Process

Literature review

Some of the projects are awarded on Turnkey basis which prevents multiple entities in a single project and the contractor is solely responsible for the risk of a project till handover [1]. Turnkey project is a collaborative arrangement where the project is being designed, material is being procured and constructed to achieve ready to operate condition. It is essential to employ potential Engineering agency and equipment suppliers [2]. The

fast-tracking principle is being employed to execute turnkey projects.

The Fast-tracking is a schedule compression technique. Some of the activities or events are executed in quick manner or concurrent to another event. Accelerating or overlapping has an impact on projects in terms of achieving the original objectives and sometimes may lead to unexpected outcomes [3]. Project management is a learning profession. Cost, time & quality is the main success criteria of a project and it forms IRON TRIANGLE. Subsequent to Iron triangle, other success criteria need to be considered for the project. Project team need to consider all criteria that influence the success of

the project to avoid Type-II error [4].

The success of each project lies with stakeholders involved in the project over different time scale and at different stage of the project. Success of the project doesn't stand on timely completion and within the budget, it should yield the desired outcome. Project need to be aware of risk at each stage of the project. The role of Project manager is vital as he needs to envisage the future progress and need to avoid the gap between customer demand, progress at each stage till project outcome [5].

Planning is defined as Trying to anticipate what will happen and devising ways of achieving the set of objectives and target and point out that in planning concept there are always objectives to be reached in future. The planning is a process during which efforts and decisions are made to achieve the goals at the desired time in the desired way. Project schedules are consistently dynamic. There are several factors affects the project schedule and cause delay. These factors are both controllable and uncontrollable. These factors create a negative impact on the project [6].

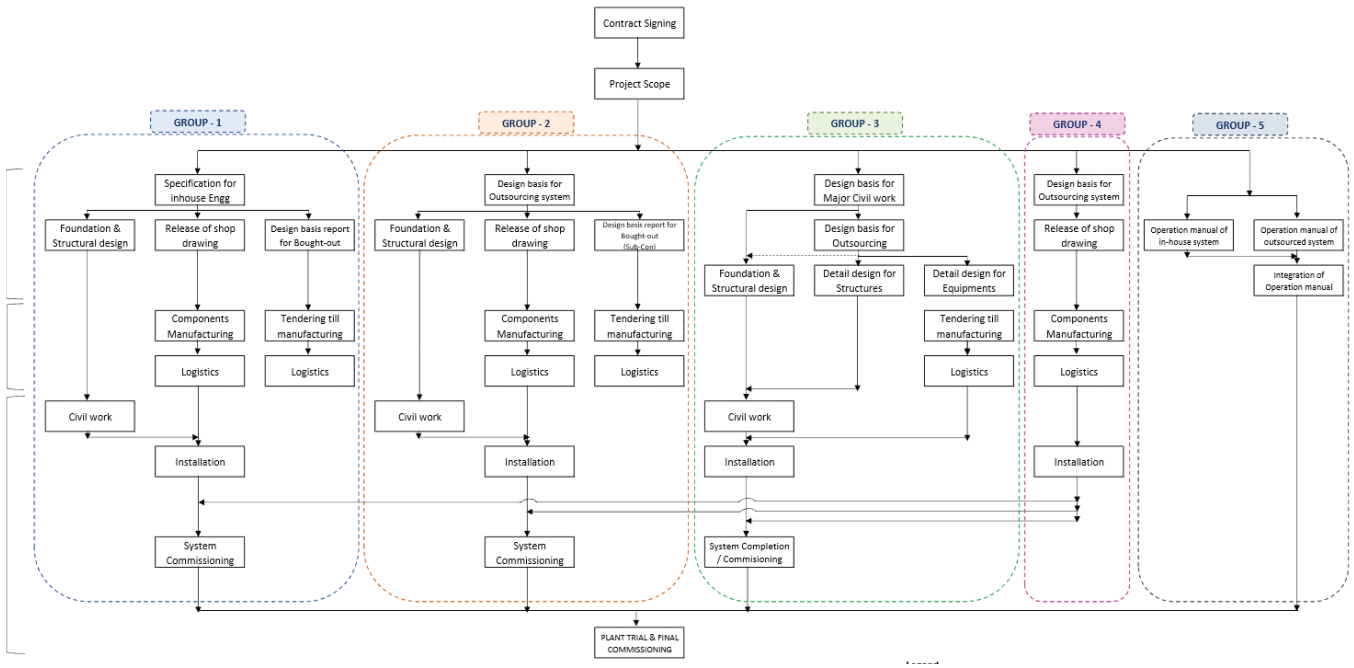
A successful project begins from Planning stage in a project life cycle. There are four key criteria that define Project success are plan development, Iron Triangle, team structure and the impact of the project manager, stakeholder satisfaction of the end deliverable. Planning is the time at which functional and technical requirements are defined; activities, processes, and resources are identified. Plan which is made at the inception of the project are not static. Plan need to be revisited as Project are influenced by external factors, change management, statutory requirement, staff turnover rate, etc [7]. Hence, the plan needs some update during the execution of the project and the changes should be within the Iron triangle which are Cost, Time & quality.

Engineering project was split into various Work packages. Each Work package is executed individually by a team and controlled by the Project Management team (PMT). PMT is the leadership team which guides each Sub-team executing Work packages. Time is the essence in executing in each Work package. Planning of Work package is based on the constructability of a project and other factor influencing the installation work. To achieve this, the Planning needs to be centralized and Planners need to interfere from the inception of the project till its completion [8].

A project is split into work area. Each work area split into work elements. Work elements are executed through Work Package namely Engineering Work package, Procurement work package, Construction work package such that execution of work area is planned through the sequence of work on constructability of the work area. In Engineering, Level-2 and Level-3 schedule are drawn with data from design Drawings, Standard Detail Drawings, Vendor Drawings, Specifications, Data Sheets, P&ID's, One Line Diagrams, Material Request for procurement material. Further, sequential links are established between Engineering, Procurement and Construction to generate Construction Work package or Field installation Work package [9].

Factors contributing to design changes are scope definition, schedule overlapping, and experience of the project team, etc. Design changes are becoming common and inevitable in large industrial projects due to intended or forced change. Many project time delays, cost overruns and quality Defects especially in the oil sector can be attributed to design changes, sometimes implemented in the belief that the changes will be beneficial for the project, but with unforeseen detrimental effects. It was found that 4 factors contribute to design change. They are Project-related factors – project size & its complexity, contract type and delivery method, level of schedule overlapping and compression; Factors related to project management practices - pre-project planning, scope definition, project management systems, tools, and procedures, design data freezing, level of stakeholders'

participation during project execution and design interdisciplinary coordination; Human-related factors - work experience, educational level, skills, personality and background, management support, and staff turnover; Change-related factors - Type of changes, timing of change occurrence, frequency of changes, and processing time of changes. Poor scope definition results in design changes throughout the project, scope creep, loss of productivity, rework, increase in the total cost and project duration. There is a positive relationship between the level of project scope definition and the level of project success [10].



In most of the projects, part of work or scope being outsourced to the vendor and aimed to reduce costs, provide agility, flexibility, concentration of efforts in activities with higher added value. Again, the vendor offload part of their scope to their sub-contractors. Thus, the result is based on the joint effort of different companies / stake holders. Project manager of performing organization is the sole responsible for any cause. He needs to develop performance indicator during execution of the project [11]. In European Construction Institute Fast-Tracking Manual, two-thirds of the project managers asked to develop a risk management process to deal with penalties as a result of applying fast-tracking [12].

Successful risk allocation requires one to identify and evaluate the risk allocation criteria, which interact and overlap with each other and can lead to significant variation in the decision outcome in risk allocation. Risk in EPC projects are project complexity such as interdependencies associated with activities, phase overlap, operation fragmentation, and contractual concession terms and investment. The risk assessment is done by Identify risk through literature, preparing questionnaire, expert advice. Then, ANP network to be built by clustering or grouping the risk. Draw out the relationship or dependency among risk through comparison matrices between various criteria groups and the various criteria factors within the same group. Through expert advice, value the relationship to find consistency. Thus, the risk is quantified. Then, allocate the risk to team as per their capability [13]. Finally, it is mandatory for proper planning, scheduling and training to the team to avoid variation in design [14].

NECESSITY OF ALTERNATIVE METHOD

Various research is being carried out to improve the performance of Engineering phase of the project. In some of the case studies, the performance upgradation is being carried out through questionnaires from

subject matter experts, professionals from Senior management to Junior role. The questionnaire is based on the challenges they experienced in projects over the year. In most of the case, the challenges that hit the list are the major concern in design phase which will be the Engineering of critical system, Engineering release for long lead bought-outs, etc. In some of the case studies, project was split into various work packages and E, P, C principle applied to each package and consolidated to the project. In real-time project, each part / module of the project has interface or interferences which will influence other Work package at the start or at ongoing stage of Engineering process.

Each project is designed for operability and drawings are released in sequence for Constructability. Also, concern like interface among system/package, decision on offloading of work, statutory clearance, etc need to be addressed on time because every concern will lead to risk.

PROPOSED METHODOLOGY

New method of identifying the risk been proposed in this methodology. The experienced earned through the period will guide us on identifying the risk but some of the underlying risk will be unaware by the team during the initial stage of project. This underlying risk will grow over the course of time and its risk magnitude will challenge the project objective. Instead of dealing with the major concern in the Engineering phase, the whole Engineering phase need to be subjected to scrutiny. This is possible from the Planning stage of the project by drilling down the Engineering activities planned throughout the Project life cycle. This breakdown methodology supports both Planning of activities and identifying the risk such that planning and risk identification need to be done concurrently. Mathematically, it is expressed in relation as

Detail Planning α Risk identification α Meeting the Project objective

The breaking down of Engineering phase is done by considering

- The scope of the project,
- Capacity of the performing organization (turnkey contractor) for inhouse Engineering & manufacturing.
- Outsourcing companies or vendor based on their service required for the project.

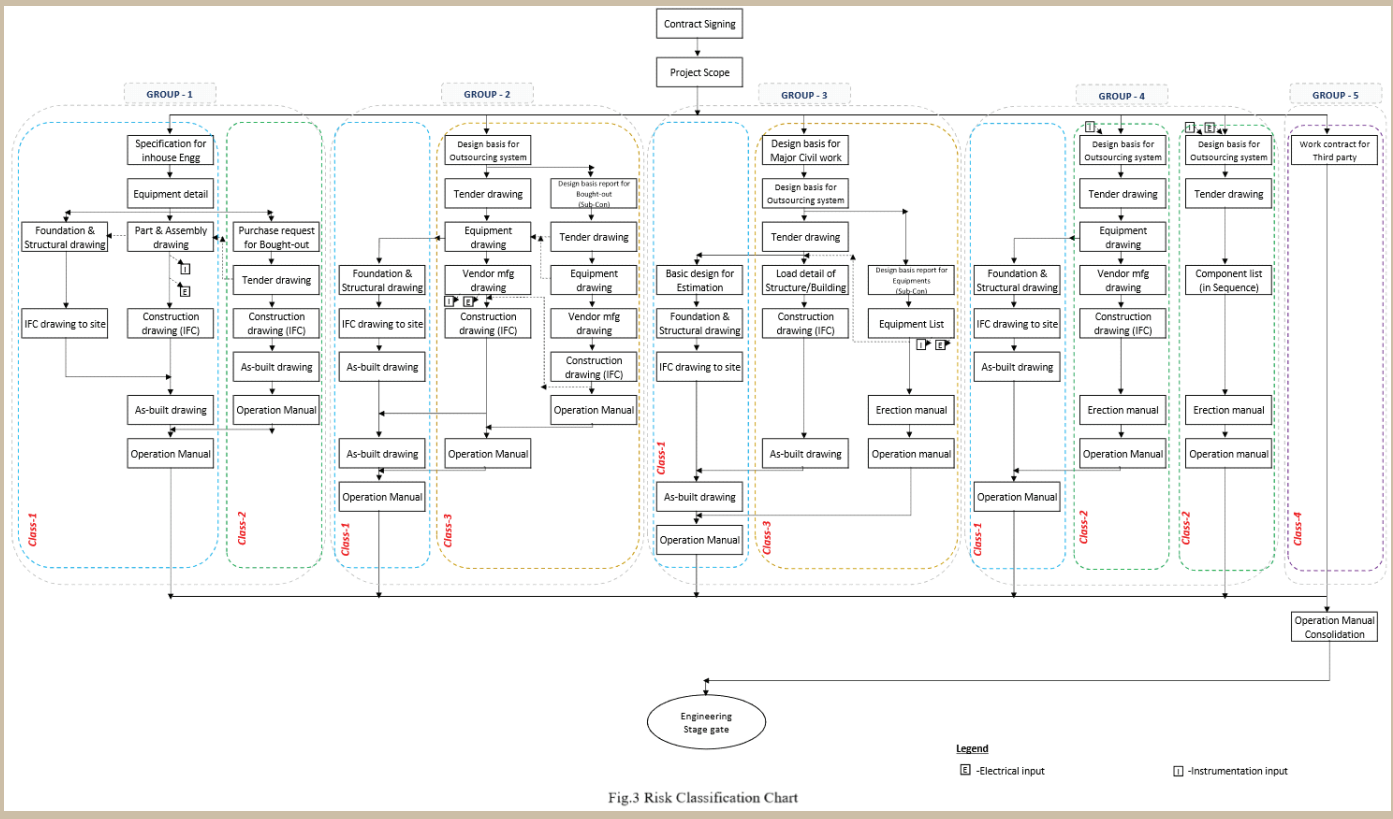


Fig.3 Risk Classification Chart

Let us consider a scenario mentioned in Fig.2 that the turnkey contractor possesses limited manufacturing capability & inhouse engineering and decide to off-load few systems to third parties. The outsourcing may be on EPC basis, EPCM basis, supply contract or service contract. Based on the scenario of the performing organization, the scope of work among the stakeholders are classified into group (Group-1, Group-2, etc). This grouping of stakeholders towards project objective need to be done at the initial stage of Engineering planning. Based on the capability of performing organization there will be 'n' times of Group-1, Group-2, Group-3, Group-4 or Group-5. Also, it needs to be visited at each stage of the project and need a periodical update.

Based on grouping of stakeholders, Engineering activities need to be performed by each group are further drilled down as shown in Fig.3 is the next stage of Engineering planning.

In Fast-Track project, each phase is concurrent. The civil work for major building needs to commence at the initial stage of Construction phase. Hence, performing organisation need to release the foundation and structural drawing on top priority. To release such civil drawing the performing organization may independently release construction drawings based on the authentic input or need the influence of vendor for load details and other input. If vendor influence is more on releasing such priority drawings, then there is a trigger on risk in form of budget by engaging vendor at an early stage or in form of schedule by delay in engaging vendor that reflects on late release of civil drawings.

Scope bifurcation among the stakeholders in a project are listed below,

- The performing organization possess manufacturing capability for the major system of the project but few or a part of the component need to be outsourced to sub-contractor. Thus, there is further bifurcation of Engineering work in each group. It falls under Group-1.
- Few major packages will be offloaded on EPC or EPCM basis. Engineering of this component plays a major role as some of the input is exchanged between performing organization and vendor in the project. It falls under Group-2.
- The tall structure or complex buildings like utility buildings will be outsourced. Again, there will be a bifurcation in Engineering activities among stakeholders from performing organization, vendor to sub-contractor of vendors. It falls under Group-3.
- Some of bought-out item will be procured based on the specification released by the performing organization on supply contract. These systems have an interface with another system. Cabling, power & control panel design, piping are notable example of this category. It falls under Group-4.
- Finally, service contract on the third part agency on consolidating Erection and operation manual of the project. It falls under Group-5. This contract may be optional as it is the sole decision of performing organization to engage a third party.

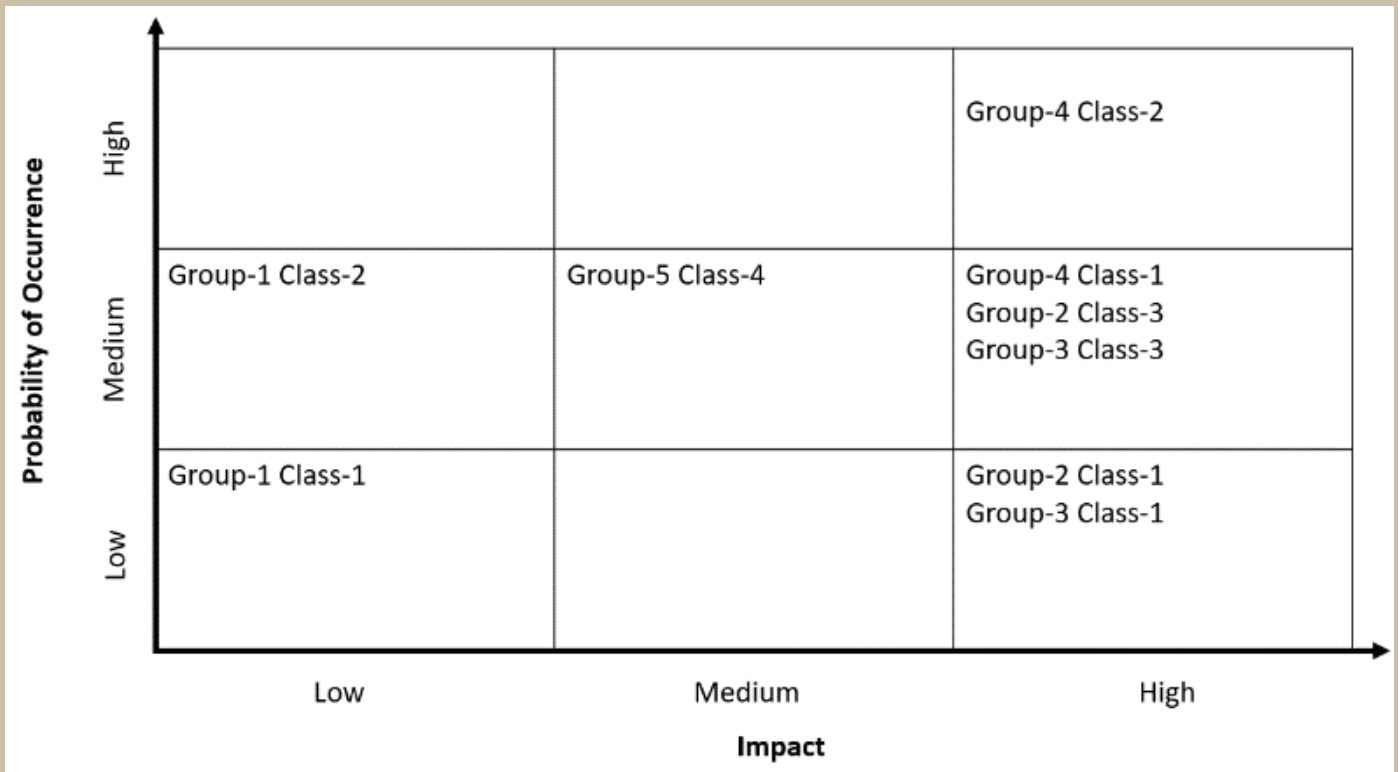


Fig.4 Risk Categorization Matrix

Based on the breaking down of Engineering activities the risk will be easily visible. The risk identified in each group are classified as Class as shown in Fig.3. The risk is classified in various segments based on design being done by each stakeholder and their control over their task. Engineering done by performing organization classified as Class-1 which envelopes the design of complete system or partial design of a system. If Civil & structural Engineering work is performed by the vendor or any third party, then the classification number will change.

Complete Engineering work performed by vendor without influence of sub-contractor or any external agency classified as Class-2, whereas any influence of external agency on vendor classified as Class-3. Off-loading of any service work by performing organization like consolidation of Erection and Operational manual falls in Class-4.

At the initial stage of Engineering phase, the system under the control of vendor or other third party possess high risk than the system directly executed by performing organization.

Risk assessment is the next stage after risk identification. It is best to mitigate the risk than responding to the risk [15]. Among various tools in risk assessment, FMEA (Failure Mode Effective Analysis) is a suitable tool to assess and manage risk. Merits of FMEA are - it supports prevention planning, identifies the change requirement, increased throughput, reduces delay or idle time. As the Engineering phase is a process, FMEA is the right choice to identify potential failure mode & its effect, develop a ranked list of potential failure modes, establishing a priority system for corrective action considerations [16].

TABLE 1 Project FMEA

S. No	Group	Class	System or Package	Stakeholder (Agency)	Project Risk	Potential cause	Probability	Impact	RPN	Action	Due Date	Responsible	Completed	New Probability of Occurance	RPN (revised)
	Group-1	Class-1													
	Group-1	Class-2													
	Group-2	Class-1													
	Group-2	Class-3													
	Group-3	Class-1													
	Group-3	Class-3													
	Group-4	Class-1													
	Group-4	Class-2													
	Group-5	Class-4													

The 'Project FMEA' is a modified version of FMEA is a suitable type to assess risk. The team need to rate the potential risk and need to reach consensus [17]. The risk identified are listed down in the table against dedicated column of Group & Class, associated system or package and corresponding stakeholder as shown in Table-1.

This helps us to identify

Risk which is anticipated to arise from the stage of Engineering process

The executing agency.

Engineering interface between performing organization & vendor, between vendor & their sub-contractor.

Then, the team prioritizes the risk by calculating the product of the probability of occurrence and impact on the project. More attention needs to be given in risk rating because there may be a tie in the calculated Risk or Risk priority number (RPN)which will misguide the mitigation plan.

Risk mitigation will be carried out by periodical review of FMEA by allocating a responsible person and fixing the target date, re-assessing of Risk priority number.

In some cases, RPN produce identical values among risk. In case of disagreement Risk Priority Code (RPC) may solve the tie situation [18]. In the other method, risk can be mitigated based on time dependency of risk [15].

From the calculated Risk or RPN risk are categorized in 'Risk Categorization matrix' [17]. For an illustration, risk among the system/package at the inception of the project shown in Fig-4. The Risk Categorization matrix needs to be updated periodically after review of FMEA as risk level will change during the course of action.

BENEFIT OF NEW METHODOLOGY

This methodology supports us in identifying the risk from inception of the Project, risk occurred at the stage of Engineering process and responsible agency or stakeholder.

In the design & build environment, designers and constructor participate in look ahead and make-ready planning session. All the concerns related to design are reviewed discussed in accordance with the site condition. This increases the performance of the project [19]. In the fast-track project, Engineering phase are concurrent to Procurement and Construction phase in some occasion. This methodology will support them in solving the ambiguity of Procurement and Construction activities. Concurrently, Risk Categorization chart will be portraying the update of project risk raised from the variation or changes experience in Engineering, Procurement and site activities.

Conclusion

A new approach in identifying the risk has been elaborated in this paper which authenticates full control on the Engineering phase. As the Engineering phase drives each phase of a project, identification and control of risk is essential. The project manager needs to kick start detail planning of Engineering activities in the planning phase of the project because he/she is responsible for delay occurred by his team, vendor & their contractors. Also, the team needs to be competent to identify the risk along with the planning of activities. The plan may change during the execution of project based on site requirements like resource availability, client requirement, statutory requirement of the project, vendor input,etc to meet the project triangle. The risk will also change along with the plan. Vendor may offload part of their scope to vendor or third party in course of execution of Engineering phase. In such a case, there will be a transfer of risk to an external agency. These changes need to be updated in the schedule by the performing organization, risk needs to be identified and the identified risk needs to be assessed through FMEA. In the fast-track project, Project Engineer (PE) dealt with interdisciplinary co-ordination among various disciplines and different Work packages [20]. Hence, the planning of work and risk identification needs to be carried out meticulously. Moreover, this methodology supports the team particularly for Project Manager, Engineering Manager, Project Engineer and Project Controller.

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Torsional Behavior of Artificially Degraded Steel I Section Externally Bonded with GFRP, BFRP & CFRP

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Abstract - The oil and gas industry is highly demanding when it comes to the application of structural steel. Steel beams and girders are commonly used steel sections in the oil and gas industry. The main reasons of deterioration of these structural steel members are corrosion and ageing. Welding of additional steel plate is conventional strengthening method for these deteriorated steel members. Welding of additional plate increase the dead load and also susceptible for corrosion. These additional plates are huge, heavy; required heavy equipment's to fix it. Due to these disadvantages there is necessity to find alternative for repairing and strengthening of steel structures. Strengthening of steel structures by using FRP (Fiber Reinforced Polymer) is appearing to be excellent solution for these disadvantages. FRP offers advantages such as high strength-to-weight ratio, effortlessness drilling and anchoring, high corrosion resistance and high resistance to chemical attacks. FRP laminates formed via the wet lay-up process due to which FRP laminates follows the curve and irregular surfaces of parent structure. The main aim of this paper is to study the torsional behavior of artificially degraded steel I section externally bonded with Glass fiber polymer sheet, Basalt fiber polymer sheet, and Carbon fiber polymer sheet.

Keywords –Torsion; Steel; FRP; GFRP; BFRP; CFRP

Introduction

Steel is widely used for almost every type of structure as it gives the advantages like it takes less time for construction, it can be recycled and offers flexibility in construction. It has disadvantages such as it undergoes corrosion action due to different environmental conditions and also gets deteriorated due to aging. These problems affect the service life of the structure. The conventional method of retrofitting and strengthening of steel structures is to remove old member and replace it with new one or to attach external steel plates. But these plates do not take the shape of parent structure, steel parts are generally heavy, difficult to fix and also have tendency to corrode. Due to these disadvantages there is a need to look for an alternative solution. The use of Fibre Reinforced Polymer (FRP) appears to be an excellent solution. It has advantages such as high strength to height ratio, high corrosion resistance, high resistance to chemical attacks, less operational cost . Also FRP laminates take the shape of parent

structure by following curve and irregular shape of parent structure. Glass fiber-reinforced polymer (GFRP) composites and carbon fibre-reinforced polymer (CFRP) composites are most commonly used composites. Basalt fibre-reinforced polymer (BFRP) composites are not commonly used as compared to Glass fibre-reinforced polymer (GFRP) composites and carbon fibre-reinforced polymer (CFRP). Structural members which are used in oil and gas industry which are curved in plan, eccentrically loaded beams, curved box girders spandrel beams and spiral stair-cases are typical examples of the structural elements subjected to torsional moments and torsion cannot be neglected while designing such members. If the structural member become deficient in torsional capacity, there is need to improve it

test set up and material

A. Test Set Up

The test set up is shown in Fig.1. In test setup, Beams were arranged with box type arrangement and lever arm at both ends. This arrangement placed over roller support. Roller supports were fixed at bottom of box. These supports make sure that the beam was free to rotate in opposite direction. This setup was fixed under Universal Testing Machine (UTM). The load was applied by UTM on diagonally placed loading girder. Then this central load was distributed over two lever arms as point loads through loading pin. The angle of twist was measured by using 'Precision Measurement' instrument in degrees.

B. Material

12 artificially degraded steel I-beams with circular shape bonded with and without FRP sheets respectively were used to study the torsional behaviour. The most widely used epoxy resin namely "Araldite", available as resin and hardener in separate packages has been used for bonding the FRP strips on the steel beams. The GFRP, BFRP and CFRP sheets used for strengthen the artificially degraded steel I section has properties listed in Table 1

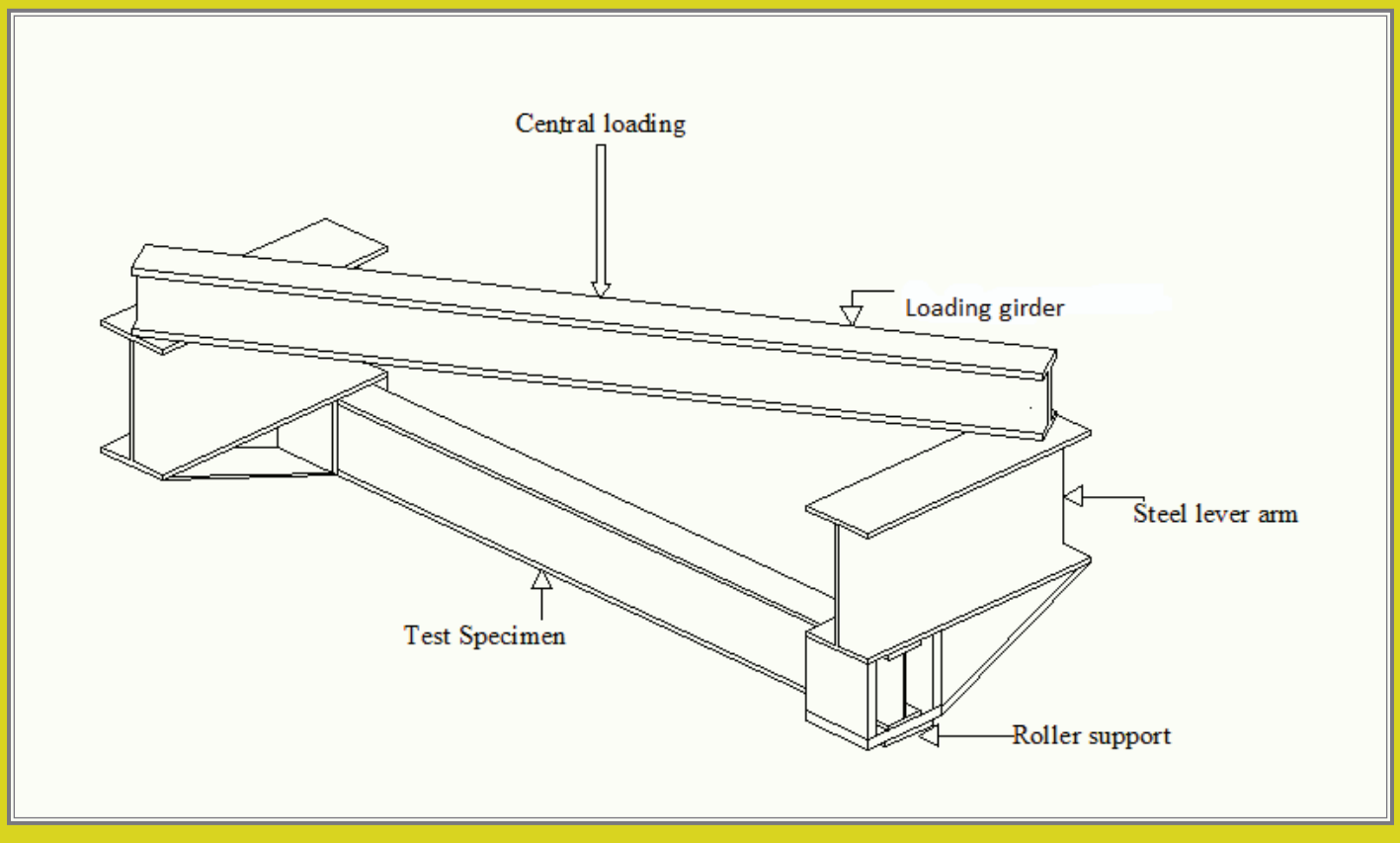

TABLE I
(Properties of GFRP, BFRP and CFRP)

`	Glass fibre	Basalt fibre	Carbon fibre
Modulus of Elasticity	76 GPA	89 GPA	600 GPA
Poisson Ration	0.27	0.26	0.27
Density	2770 kg/m3	2650 kg/m3	1800 kg/m3
Type of material	Isotropic	Isotropic	Isotropic
Fibre direction	Unidirectional	Unidirectional	Unidirectional
Thickness	0.5 mm	0.5 mm	0.5 mm

Artificially degraded steel I section with circular notch and rectangular notch are shown in fig. 2 and fig. 3 respectively

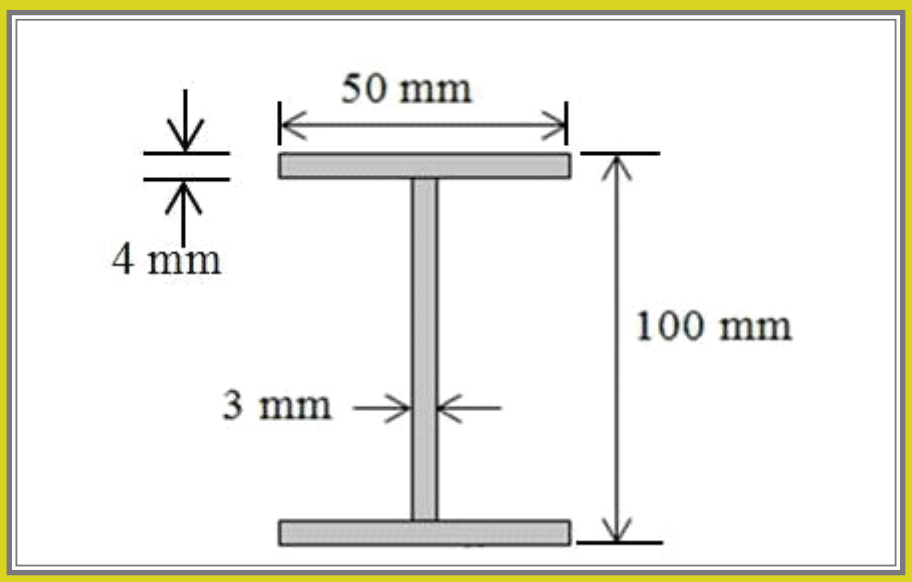

Fig. 2 Details of Steel I section

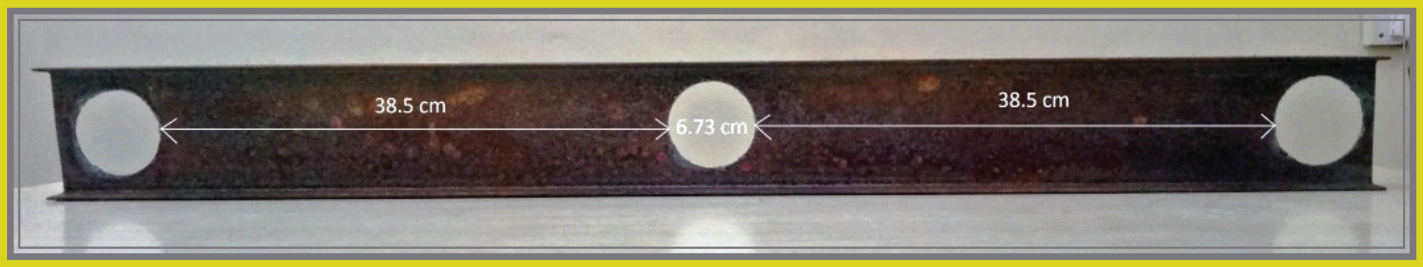

Fig. 3 Artificially degraded steel I section with circular shape notching

Preparation of Test Specimen & Testing

A. Preparation of test specimen

The sections with the layer FRP laminates were prepared by following proper steps. The first step was to have the surface preparation process which was completed before applying FRP strips. The surface of the beam specimen was cleaned by grinding to remove rust and impurities. The surface was made slightly rough by using sand paper. This roughness is necessary to have proper bonding between adhesive and steel surface. The layer epoxy was applied on the surface of beam by brush to maintain uniform thickness throughout the length. After this, FRP strip was placed over the epoxy layer with help of roller. This roller was used in direction of fibre to remove excess epoxy and air pockets. Two types of sections were prepared such as FRP is placed at three sides of steel I section (Tension or compression and both sides of web) and FRP is placed at all sides of steel I section (Tension, compression and both sides of web)

B. Testing

The test specimens bonded with GFRP, BFRP and CFRP were tested under universal testing machine as shown in fig.4. The angle of twist was measured by using 'Precision Measurement' instrument in degrees as shown in fig 9.

Fig. 4 Experimental setup for torsion

Experiment Results

Table II
(Experiment results- Relation between Angle of twist and Torsional Moment for artificially degraded section by Circular shape externally bonded with GFRP, BFRP, and CFRP)

Sr. No	Moment	virgin	Experimental Results (Angle Of Twist)		Experimental Results (Angle Of Twist)		Experimental Results (Angle Of Twist)	
			GFRP three Side Wrapped	GFRP all Side Wrapped	BFRP all Side Wrapped	BFRP three Side Wrapped	CFRP all Side Wrapped	CFRP three Side Wrapped
1	62.5	2	2	2	1.25	1.2	0.9	0.85
2	125	5	3.8	3	3.4	2.4	1.8	1.8
3	187.5	6.66	5.3	4.5	5.26	4.16	2.23	1.9
4	250	9	8.5	7	7.4	6.5	3.3	2.6
5	312.5	11.25	9.5	8.5	9.25	8	4.67	2.82
6	375	13.5	11.4	10.3	11.9	9.9	5.93	4.5
7	437.5	15.75	13.1	12.25	12.95	11.9	7.63	6.55
8	500	18	15.2	14.1	14.97	13	8.6	7.97
9	562.5	21	18.1	17	18	16	9.13	8.1
10	625	24	19.5	20	18.27	18.1	8.53	8.27
11	687.5	25.83	22.3	21.83	21.56	19.76	10.59	8.23
12	750	27.66	24.1	23.66	23.03	21.33	12.5	9.3
13	812.5	29.5	26.2	25.5	24.1	23.1	13.67	9.67
14	875	31.33	27.9	27.33	25.96	25.76	14.36	11.59
15	937.5	33.16	30	29.16	27.6	27.33	16.56	13.66
16	1000	35	31.75	30.1	29.6	28.3	18.08	16.02

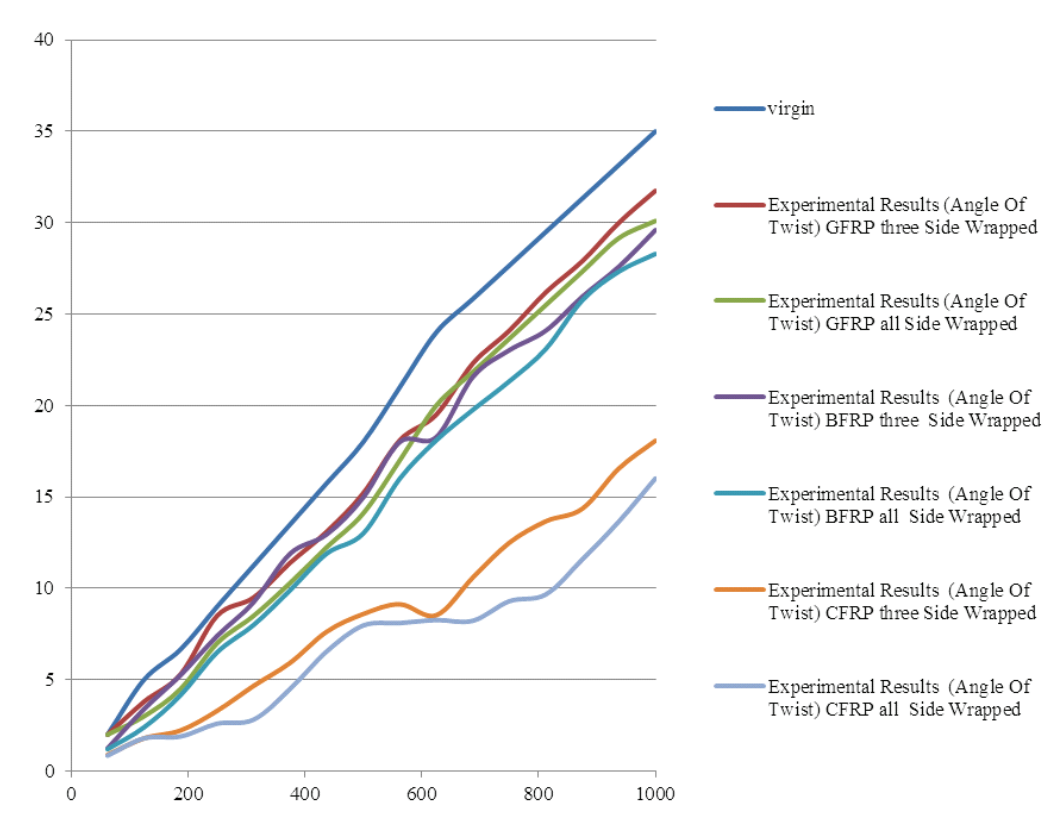

Fig. 5 Graph Showing Relation between Angle of twist and Torsional Moment for artificially Degraded section by Circular shape externally bonded with GFRP, BFRP, and CFRP.

Discussion

Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP, BFRP and CFRP has been reduced as compaired to Angle of twist for artificially degraded steel I section with circular notch

1) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP , at three side is less than deflection of artificially degraded steel I section with circular notch by 48.34%.
2) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP , at all side is less than deflection of artificially degraded steel I section with circular notch by 54.23%.
3) Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP , at three side is less than deflection of artificially degraded steel I section with circular notch by 15.43%.
4) Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP , at all side is less than deflection of artificially degraded steel I section with circular notch by 19.14%.
5) Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP , at three side is less than deflection of artificially degraded steel I section with circular notch by 9.29%.
6) Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP , at all side is less than deflection of artificially degraded steel I section with circular notch by 14.0%..
7) Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP at three sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP at three sides by 6.77%.
8) Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP at all sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP at all sides by 5.98%.
9) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP at three sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP at three sides by 43.06%.
10) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP at all sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with GFRP at all sides by 46.78%.
11) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP at three sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP at three sides by 38.92%.
12) Angle of twist for artificially degraded steel I section with circular notch externally bonded with CFRP at all sides, is less than Angle of twist for artificially degraded steel I section with circular notch externally bonded with BFRP at all sides by 43.39%.

Conclusion

From experiment results and discussion, it was observed that angle of twist has been reduced in case of steel sections externally bonded with GFRP, BFRP and CFRP . Steel sections externally bonded with CFRP have less angle of twist as compared to steel angle externally bonded with BFRP and CFRP.Also if we compared steel sections externally bonded with BFRP and GFRP , BFRP bonded steel I sections have less angle of twist as compared to GFRP bonded steel I sections.For strengthening of a steel structure with BFRP is preferred over strengthening of steel structure with GFRP AND CFRP because BFRP is green product, can be recycled, it has unlimited resources of raw product (Basalt rock) as compared to GFRP who has very less resources of raw product (B2O3) and CFRP cannot be recycled and very costly as compared to BFRP and GFRP.

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Types of Trenchless technologies

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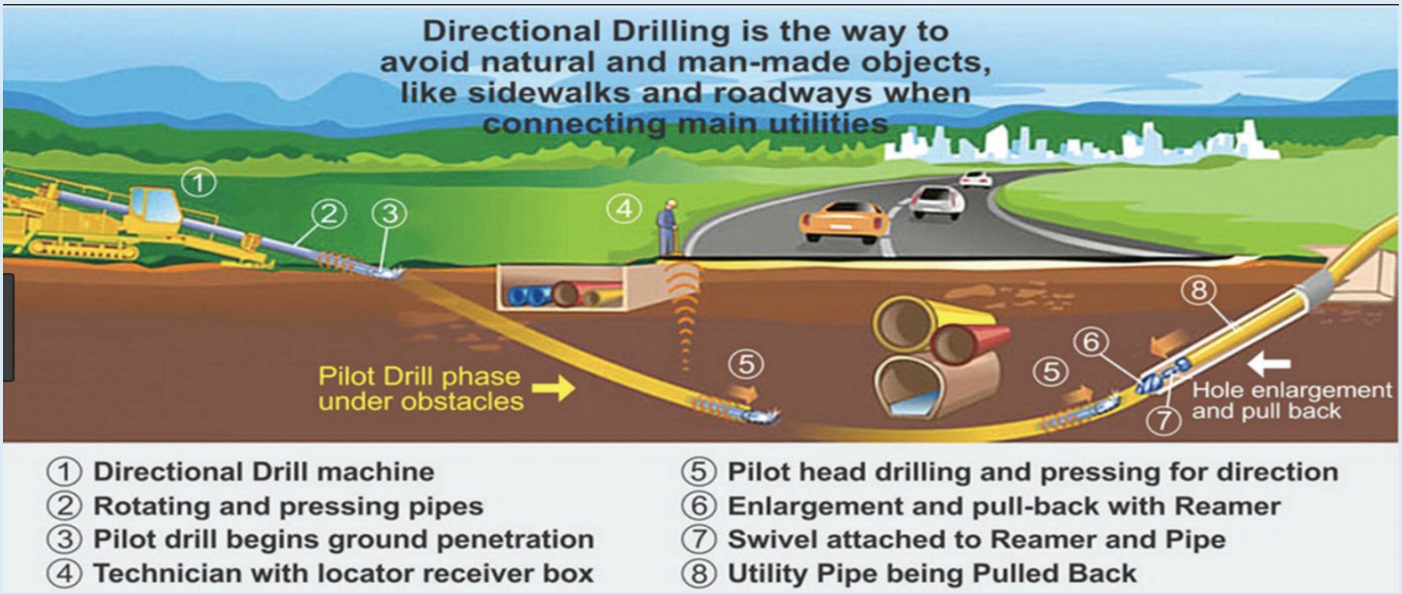
1. Horizontal Directional Drilling (HDD)

Pipe Rehabilitation – 1. Pipe Bursting & Pipe relining



Directional drilling is the practice of controlling the direction and deviation of a wellbore to a predetermined underground target or location.

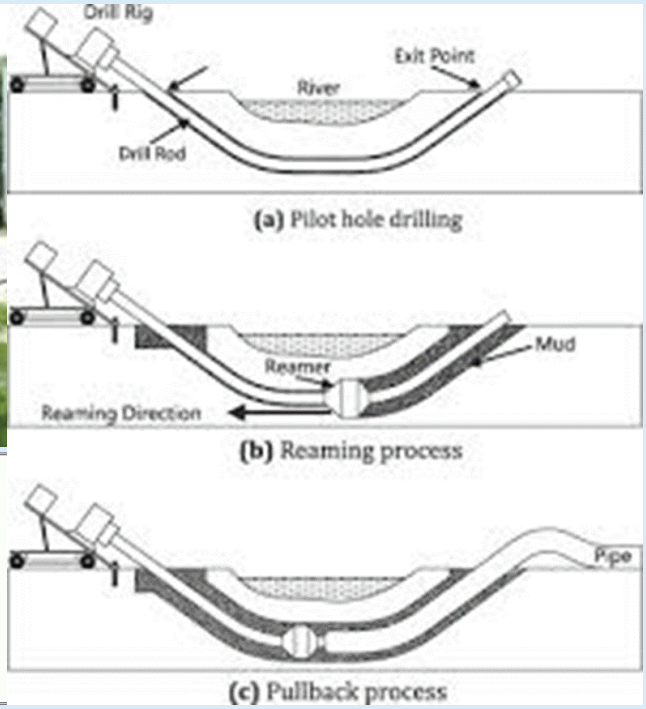
As a technique, directional drilling allows oil and gas well operators to approach a potentially productive area without the need for a well to be drilled directly above that area. A central site can service multiple well bores that reach multiple locations at non-vertical angles. This reduces the number of well facilities that must be built and maintained. Not necessary to build new wells may also lead to the exploration of smaller reservoirs that would otherwise be uneconomical. Directional drilling is also used in the development of mines in order to reduce the risk of potentially dangerous gas ruptures. In-mine drilling techniques allow companies to create bore holes far in advance of the mine face.

Although the fundamental concepts of directional drilling date back to the 19th century, it has become a more popular technique as computer-aided technology has become more common. Early directional drilling involved pointing the drill bit at an angle other than vertical, resulting in a straight line away from the well. Modern drilling techniques allow the use of the drill bits that can bend, allowing engineers to adjust the direction the well is drill in to a certain degree. This can be accomplished through the use of hydraulic jets. Moreover, the angle of the drill bit being used to bore the well can be adjusted by a computer using GPS signals to pinpoint the location of an oil and gas field. Engineers create 3-D models of the field to determine the best location for the well, and the best approach for the bore to follow.

While the ability to install underground pipework without digging large channels saves money and time, and directional drilling is rightly praised for that, it is that ability to install piping and other underground equipment without disturbing the surrounding environment that is perhaps the most important aspect. In notable projects, such as the rollout of new fiber broadband equipment by major companies, the ability to install conduit without any disruption to pavement, roads, businesses, homes, etc. not only makes directional drilling valuable, but also enables projects to be carried out when previously you would see public opposition due to the levels of disruption these projects posed.

Directional drilling is not just cost efficient and time saving, but it also enables projects that might otherwise be impractical or be delayed for years due to legal challenges to move forward. This perk of directional drilling has made it increasingly popular, and as more projects adopt drilling to avoid extensive excavation, the need for skilled directional drilling machine operators grows with it. In fact, this has become one of the most in-demand skillsets in construction today.

The full range of PE100 diameters from the smallest to a maximum diameter of around 1200mm can be installed by HDD, though the required installation length may limit the use of PE100 pipe even if a heavy wall pipe is used. Installation lengths are typically 30m and greater.



MICROTUNNELING -

When & Why do we use Micro tunnelling

To Avoid traffic disruptions and to maintain the existing operations

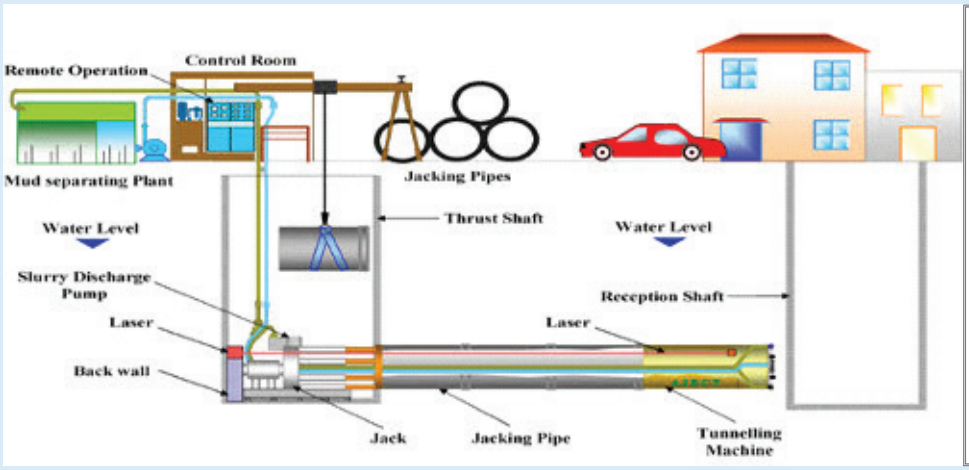
When Open trench excavations is not possible for big diameter of pipes

One of the main Prerequisite tests for Micro tunnelling

extensive Geo technical investigation along the proposed pipe alignment.

To assess the soil strata at the tunnelling depth & Ground water level

Detection of the existing under ground utilities Provision for future expansion for UG utilities corridor



General Microtunneling Process

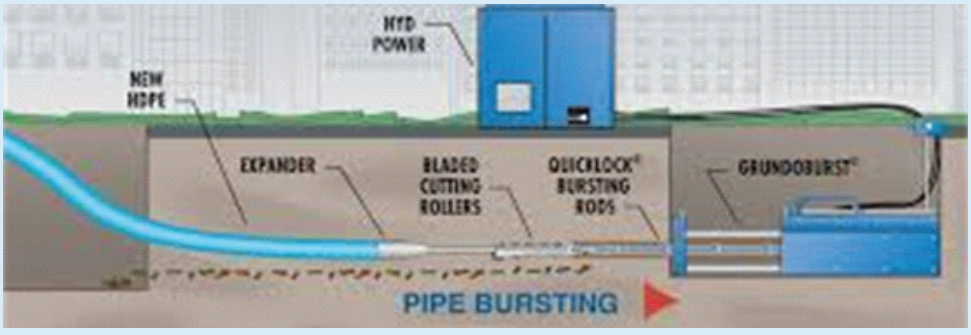
- Excavation of Launch Pit or Driving pit
- Setting up of the hydraulic Jack and the tunnel boring machine (TBM)
- Effective Dewatering System
- Bentonite Slurry circulation pit
- Excavation of Receiving pit with dewatering system.
- 24x7 power with 100% back up with Manpower

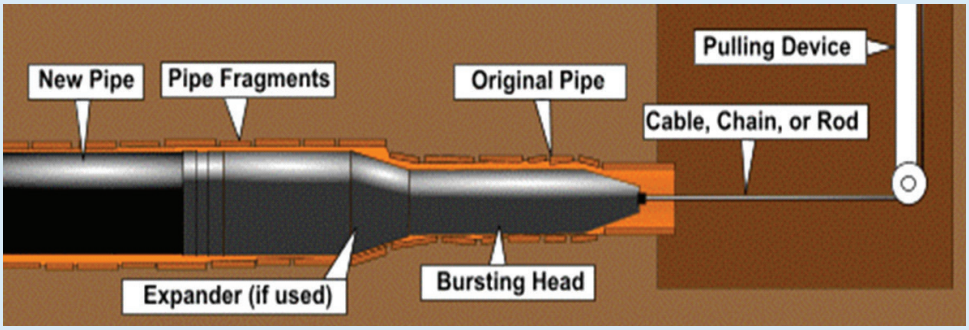
- Level of the Ground water table and design of Dewatering system and the effective disposal of the water as per statutory regulations
- Disposal of the Bentonite Slurry
- Welding of HDPE lined pipes
- Arresting the ground water leaks into the pipes
- Backfilling in a high Ground water table scenario
- Experienced TBM operator when tunnelling is relatively soft strata.
- Recovery of TBM when trapped in Soft soil pocket.
- Confined access specialist is a must procedure.
- Emergency Evacuation procedures from both the launch pit and receiving pit and regular drills

Pipe Rehabilitation works – Pipe Bursting and Pipe relining

What is Pipe Bursting Technique ??

Pipe bursting is a trenchless pipe replacement method where a large cone shape head is hydraulically pulled by steel cable through the old pipe line, breaking apart the old pipe underground while at the same time pulling into place a seamless HDPE pipe that is the same size or larger than the old pipe. Illustrated pictographically below





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Soil improvement through Vibro-Stone Column Technique – A case Study

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Abstract - The Type of subsoil present at project site has a significant impact on the project cost. In cases where soil is very weak or susceptible to liquefaction the most obvious solution is to go for deep foundations with Piles, and embed them deep till load bearing strata is found. The choice of pile foundations typically leads to increase cost over open foundations and also impacts the schedule. However with research and development in the field of geotechnical engineering there are multiple ground improvement solutions available as cost effective alternatives to the pile foundation system. Ground improvement using stone columns installed using Vibro replacement/displacement techniques proves to be a very cost effective option.

A case study of foundation for large storage tanks is included in this paper. The storage tanks made of steel plates are supported on shallow foundation having ground improvement using stone columns employed. Comparison of cost for pile foundation system and foundation for stone column is also presented for this particular case. Various installation techniques, required in-situ tests, general comparison with pile foundation and design concepts are also discussed briefly here in.

Introduction

Vibro Stone Columns can be used as an effective means of ground improvement for loose cohesion less soils e.g. silts, loose sands etc. The process involves introducing stone aggregates as a load bearing medium into in-situ soil. The Stone columns and the in situ soil then behave like an integrated system having lower compressibility and higher shear strength as compared to the un- treated soil. Stone columns provide effective drainage path thus facilitating faster consolidation of soil, thus mitigating the liquefaction risk. Stone columns also transfer load to the load bearing strata at deeper levels. The expected settlement for the same load is very much reduced and the rate of settlement is increased as compared to the untreated soils.

The technique has following benefits over untreated soil:

- Increased stiffness of the subsoil leading to reduced settlement.
- Increased shear strength to increase the bearing capacity.
- Faster rate of consolidation.
- Mitigation of liquefaction potential.
- Increased lateral capacity of piles.

Case Study - Tank Foundation

The ground improvement using stone columns was effectively utilized on one of the tank farm projects. Site fabricated steel tanks are supported on sand pad foundation with ground improvement using stone columns.

• Soil Condition at Site

In general, the sub soil below the existing ground level consisted of sandy/clayey silt layer followed by weathered rock starting from 12.5mt till the full exploration depth. Intermittent patches of sandwiched silty sands were also observed. The sub soil was compressible and hence was susceptible to excessive settlements under the imposed loads of the tanks. The bearing capacity of the soil was very low to support the proposed tanks. The intermittent sand layers encountered were susceptible to liquefaction in the event of an earthquake. Liquefaction had to be effectively mitigated due to the fact that the site is located in seismic Zone V.

- Foundation proposal
- To address the above geotechnical concerns and to provide the best cost effective solution, Ground improvement using Vibro stone column was suggested as shown in Figure 1.
- Design Concept
- The axial capacity of stone columns stems primarily from three factors, viz:
- Inclusion of a stiffer column material in the soft soils
- Densification of the surrounding soft soil during installation of the columns
- Acting as vertical drains, thus enabling faster consolidation.

The design of stone columns is achieved using the 'Heinz J. Priebes' method. The load carrying capacity of the stone column comes from the passive earth pressure developed due to the bulging effect of the columns and increased resistance to lateral deformation under super imposed surcharge loads. The surcharge due to sand pad and granular blanket further consolidates the soil and increase bearing capacity. The method is based on the assumption that the columns are based on a rigid layer and the column material is incompressible, i.e. the columns cannot fail in end bearing and any settlement of the load area results in a bulging of the column which remains constant over its length. IS 15284 Annex-A presents a detailed methodology to calculate the load capacity of stone column. Spacing of stone columns is then calculated based on the total load and pattern selected.

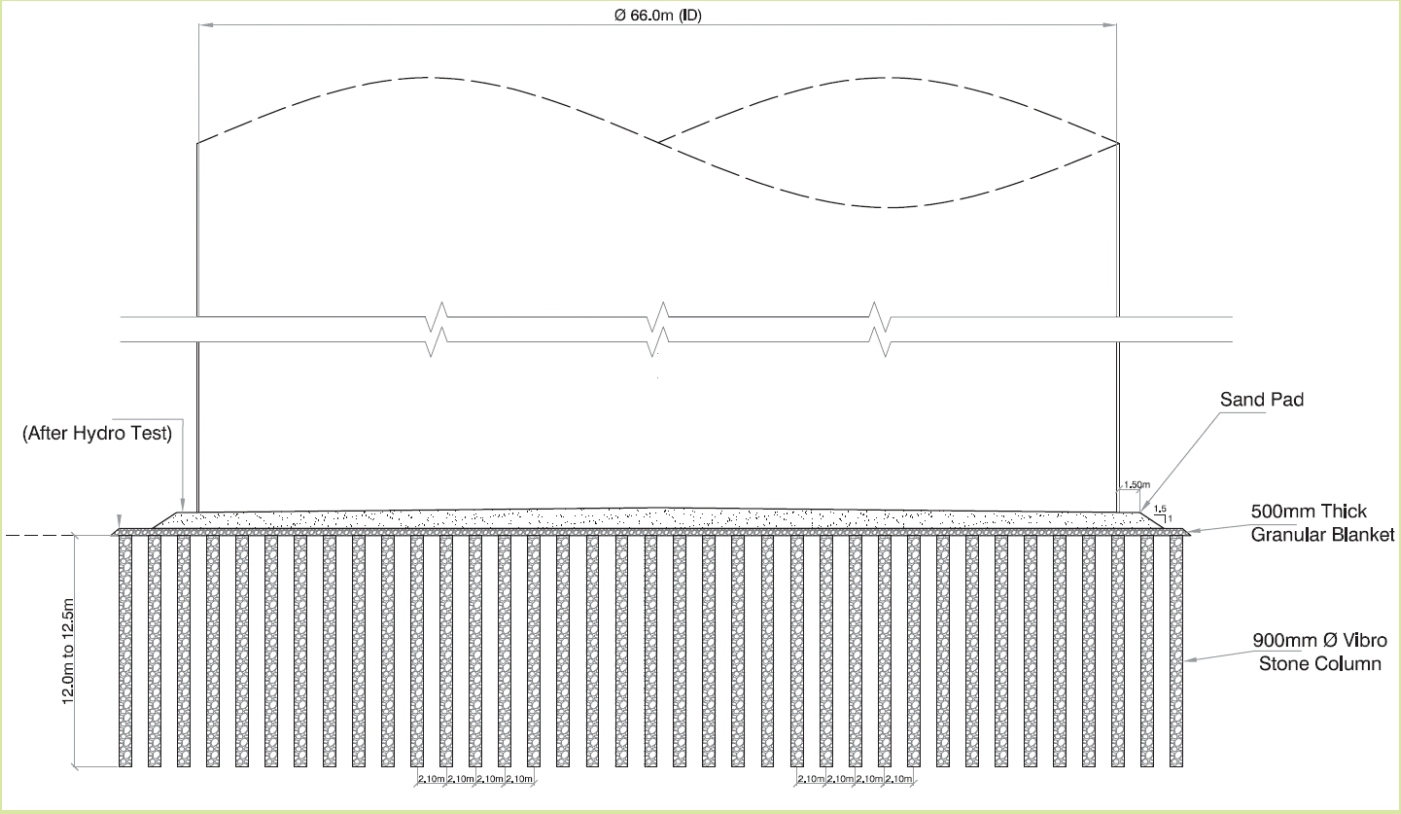
Final design of stone column pattern and spacing is an iterative process. Design calculations should be repeated till an acceptable convergence is achieved between assumed and calculated spacing.

- Adopted Treatment Scheme

Based on the tank loads and the soil in-situ condition the following treatment scheme was proposed and adopted for the project.

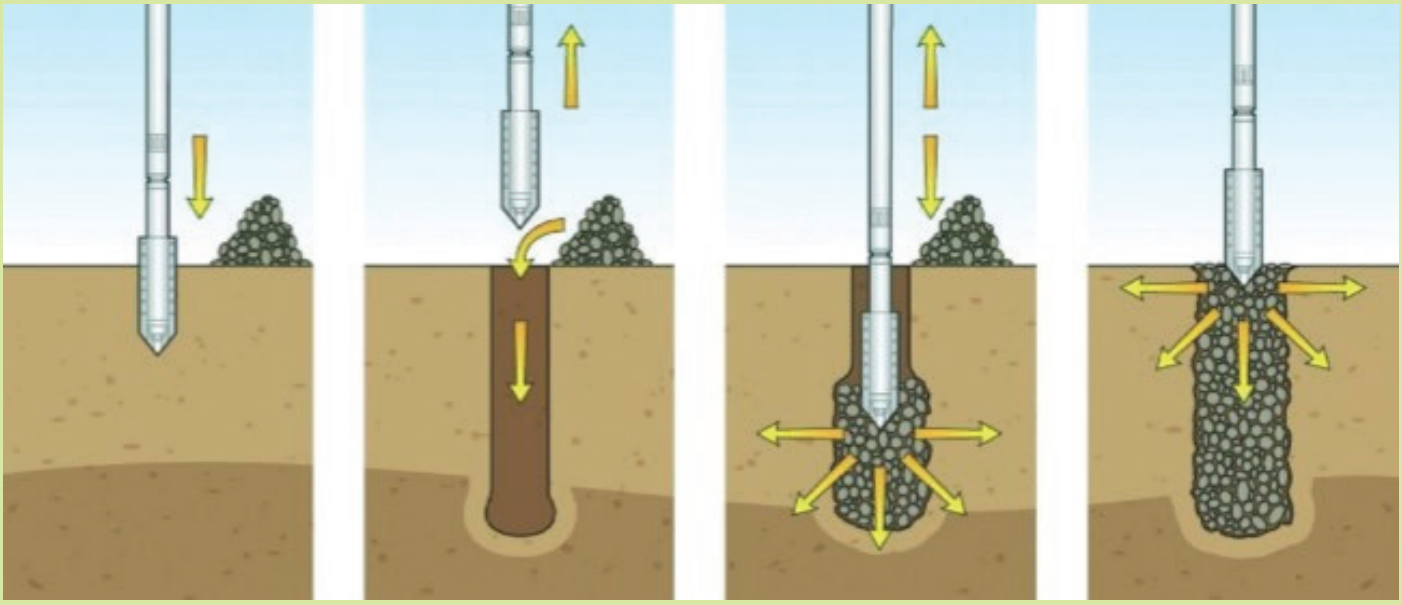
Area Replacement Ration (ARR)*	16.6% Nominal Diameter of Stone Column
900mm Spacing	2.1m C/C Grid Pattern
Equilateral Triangular Depth of Treatment	12 to 12.5m below working Platform Elevation

*Area replacement ratio is the ratio of column cross section area to total treatment area. Two extra columns rows around foot print area of tank pad were provided to ensure confinement of the soil around the foundation.



Installation technique

The construction of vibro stone columns involves drilling/driving of a hole in the ground which is then filled with granular fill / stone sand mixture and compacted. On the top of stone columns a clean gravel and sand mix with 70 to 80% relative density is laid with a minimum thickness of 0.3m as granular blanket. This layer is exposed at its periphery to the atmosphere to dissipate pore water pressure. Vibro installation methods can be broadly classified as either Displacement method or Replacement methods.



Vibro–Displacement method: In the method, native soil is displaced laterally by a vibratory probe using compressed air. This method is also known as 'Dry Method'. In this method the probe is driven in to the ground and stones are discharged through it. The stone column is compacted by the vibrations of the vibratory probe. This method leads to construction of stone columns of high integrity and tight lock with surrounding soil. While treating a large area of soil, care should be taken regarding the installation sequence to avoid the possibility of damaging nearby columns or heaving of soil.

Vibro–Replacement method: In this, native soil is replaced by stone columns, where the holes are constructed using a vibrator (vibro float) accompanied by a water jet. This method is also known as 'Wet Method'. Here jetting water is used to aid the penetration of the ground by the vibrator. Due to the jetting action part of the in situ soil is washed to the surface.

Stone columns can be installed by either a top feed or bottom-feed systems. Top feed systems can be used only when a stable hole can be formed by the vibratory probe.

In the present case, Wet Top-feed method of installation was used. In this method, the vibrator is connected to a source of electric power and high-pressure water pump for water jetting. These water jets from the tip of the vibrator assist penetration of the vibrator (vibro float) into the soil. Stone aggregates are introduced from the top and are compacted by the vibrator.

Field Tests

Field tests are performed to confirm the results of the analytical solution. This is done in two stages:

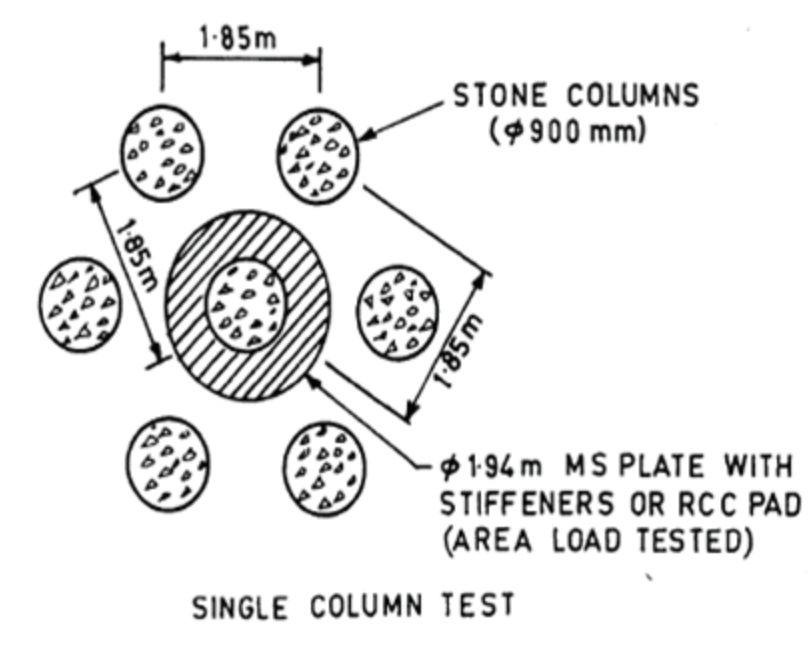
Initial field testing: This is done separately both for a 'Single Column' and also for 'Group Column'. The sample chosen for testing is representative of the general soil profile throughout the treatment area. Load settlement observations should be taken to 1.5 times the design load for a single column and three column groups. In order to simulate the actual field conditions of compaction of intervening soil, additional stone columns are to be constructed around the stone column subjected to testing. For this purpose additional 6 columns are to be constructed around the single stone column being tested. Similarly for testing a group of 3 stone columns, minimum of 12 stone columns are required forming a triangular pattern.

Routine Field testing: This is done on a larger number of Single columns and Group Columns. The test load for routine load test is 1.1 times the design load for a single column.

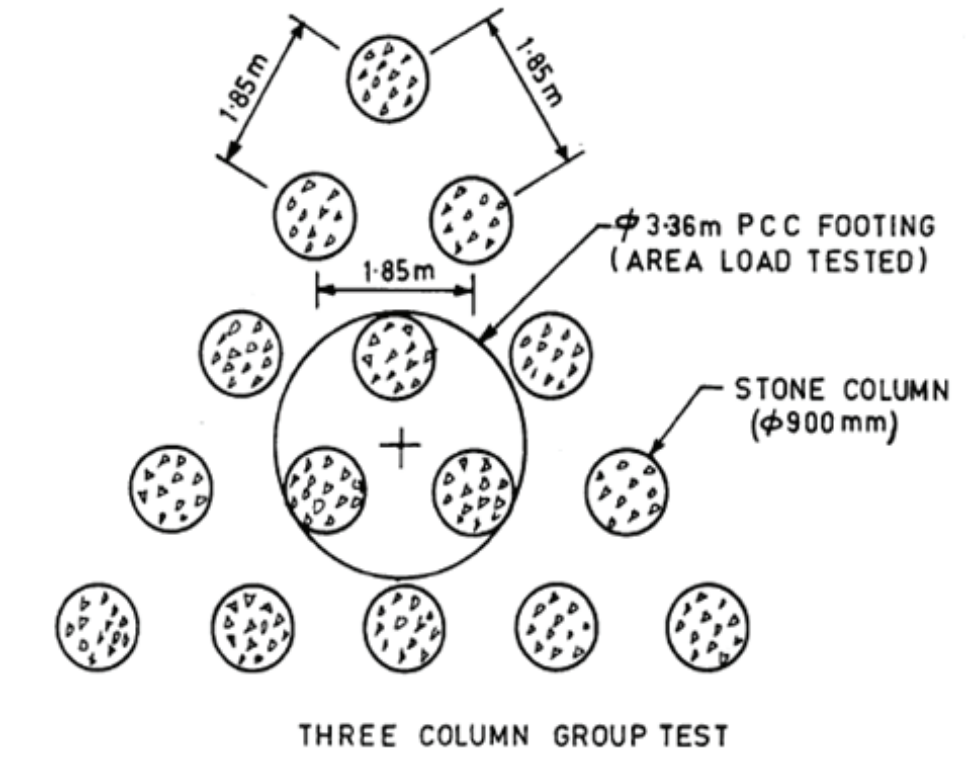
The stone columns are loaded by means hydraulic jacks. The load shall be applied gradually in increments of 20% the design load. The applied load shall be maintained for a minimum of one hour or till which time the settlement has stabilized before further increment. The test load shall be maintained

for a period of 12 hours after the stabilization of the settlement. Unloading of the test load shall also be done in similar stages, giving sufficient time for settlement stabilization. Adequate pressure and dial gauges to measure the pressure and settlement are employed. Settlement value is measured and plotted against the load.

The load test is considered to be passing if the Single Column settlement under design load is between 10-12mm and the settlement of Group Column is between 25 to 30mm. The overall setup of testing is similar to that for piles.



SINGLE COLUMN TEST



THREE COLUMN GROUP TEST

Hydro-test Method

Special care needs to be taken for conducting the hydro test of the tank. The hydro test procedure needs to be confirmed by the specialized agency performing the design and construction of stone column. Hydro test is a very import step in design of the stone column foundation since, a major part of the consolidation would occur during hydro test stage, leaving little scope for long term settlement. Slow stage hydro testing is recommended to minimize differential settlement. The height of the sand pad above grade level should be adjusted to account for the settlement during hydro test phase before start of actual operations. The following procedure was adopted for hydro test at site:

Filling rate for each stage shall not be more than 800-1000mm/Day.

Further filling for next stage shall be done only after ascertaining the settlements are Stabilized.

The rate of filling shall be reduced further on reaching 50% of tank height in the range of 450-500mm/Day.

The final stage of loading (Full tank load) shall be kept for at least 15 days or duration may increase depending on stabilization of settlements. The rate of settlement for unloading at full hydro test load shall be less than 1mm/day.

After testing, the tank shall be drained gradually holding for 24 hours at stages of 75%, 50%, 25% capacity.

Comparing Stone column with Piles.

From execution perspective the two foundation systems may be compared as below.

Pile foundations system will provide rigid foundation for which the settlement will be very less, how-

ever for stone column foundation major part of the settlement would occur during the hydro test and much less during operation.

Pile foundation would require a rigid concrete pile cap in order to transfer the weight of the tank to the piles, for stone column concrete pile cap is not required, sand pad with or without ring beam is typically provided to transfer the loads to the treated ground.

From a schedule perspective installation of stone columns foundation system (stone columns and Ring beam w/ sand pad) proves to be much faster because there is no concrete involved in the foundation system, however the hydro test duration is longer and may take up to 8 weeks depending upon the soil condition and size of the tank.

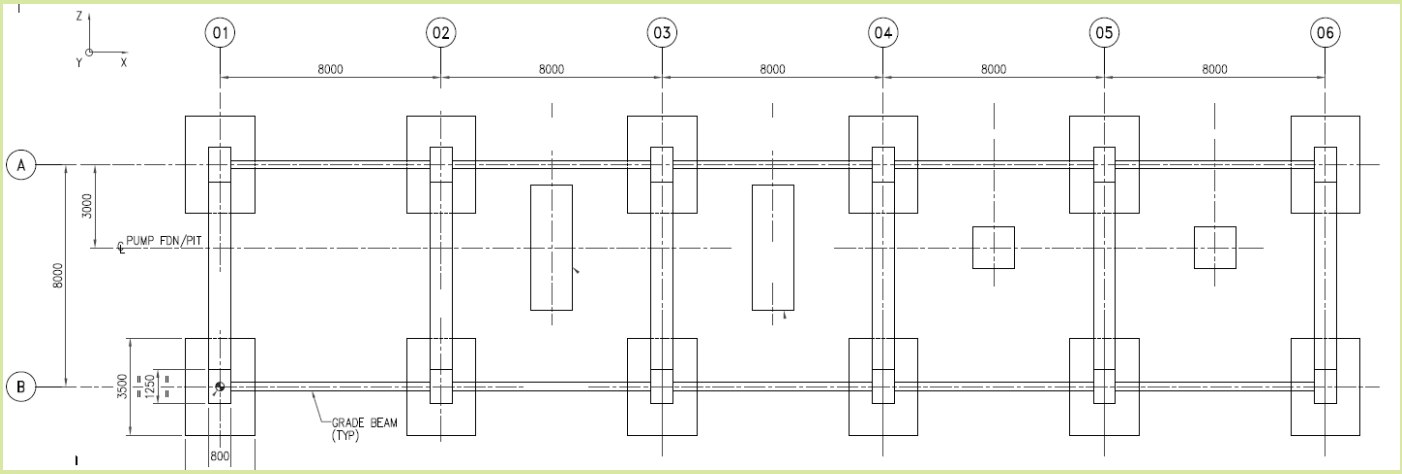
From cost perspective, stone column option will be typically economical, following table provide the cost comparison for the Tank Foundation under consideration.

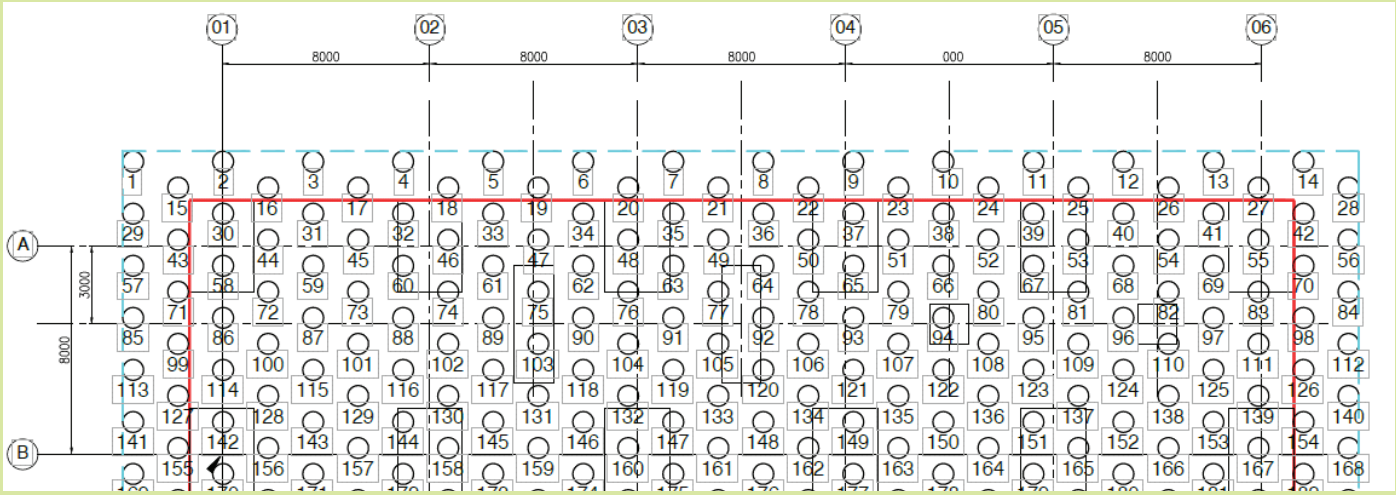
Additional benefits in terms of cost are provided in Table 2. Percentage Cost reduction recorded is of the magnitude of 60%.

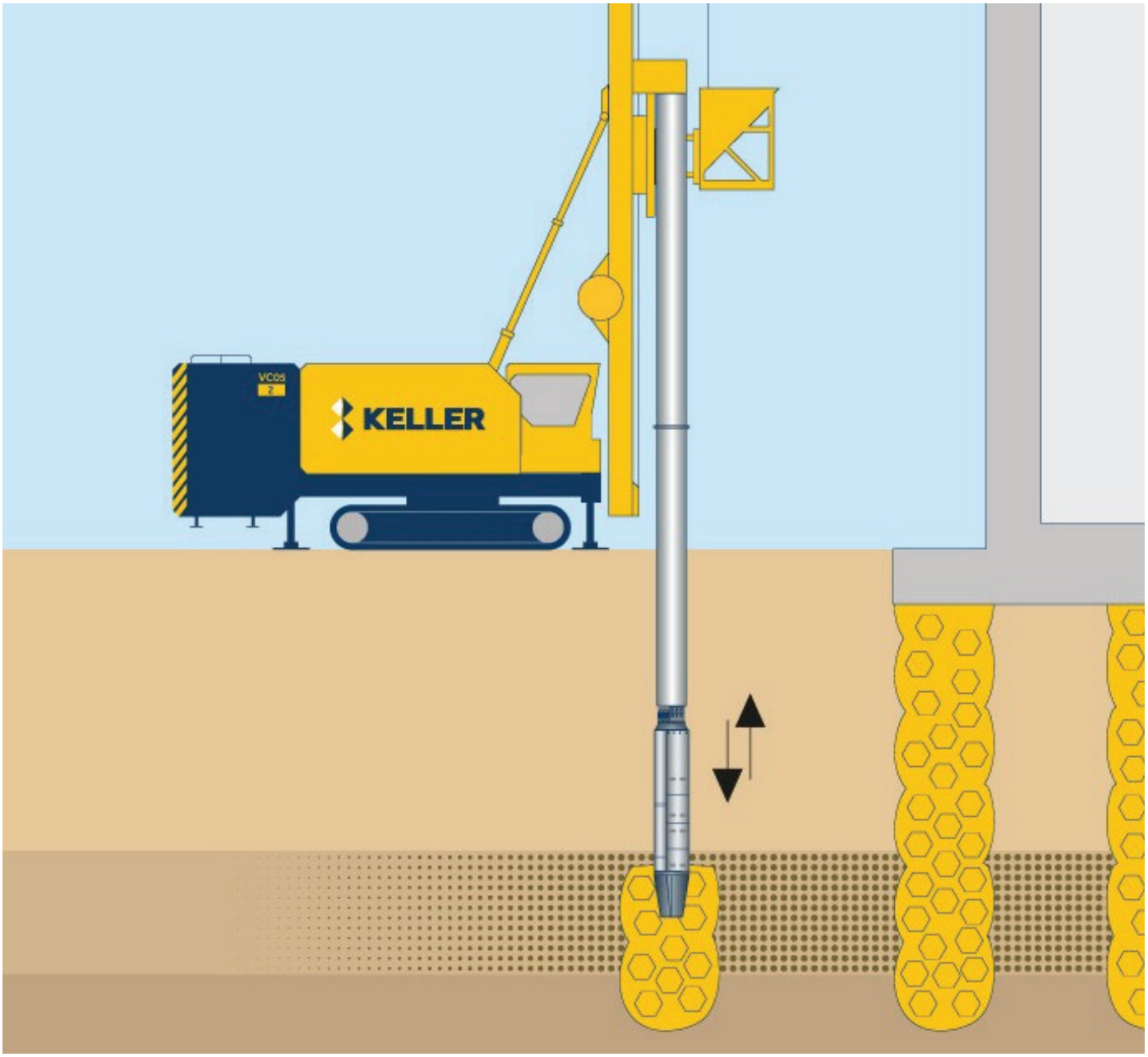
Case Study : Pump House Foundation

Ground improvement using stone column can also be used for supporting lightly loaded buildings and structures. It has been used for a pump house including small pump foundations (refer Figure 4).

The stone columns are required to be constructed in the entire area covered inside building foundations outer periphery. The area of treatment should extend beyond the foundation footprints as shown in Figure 5.





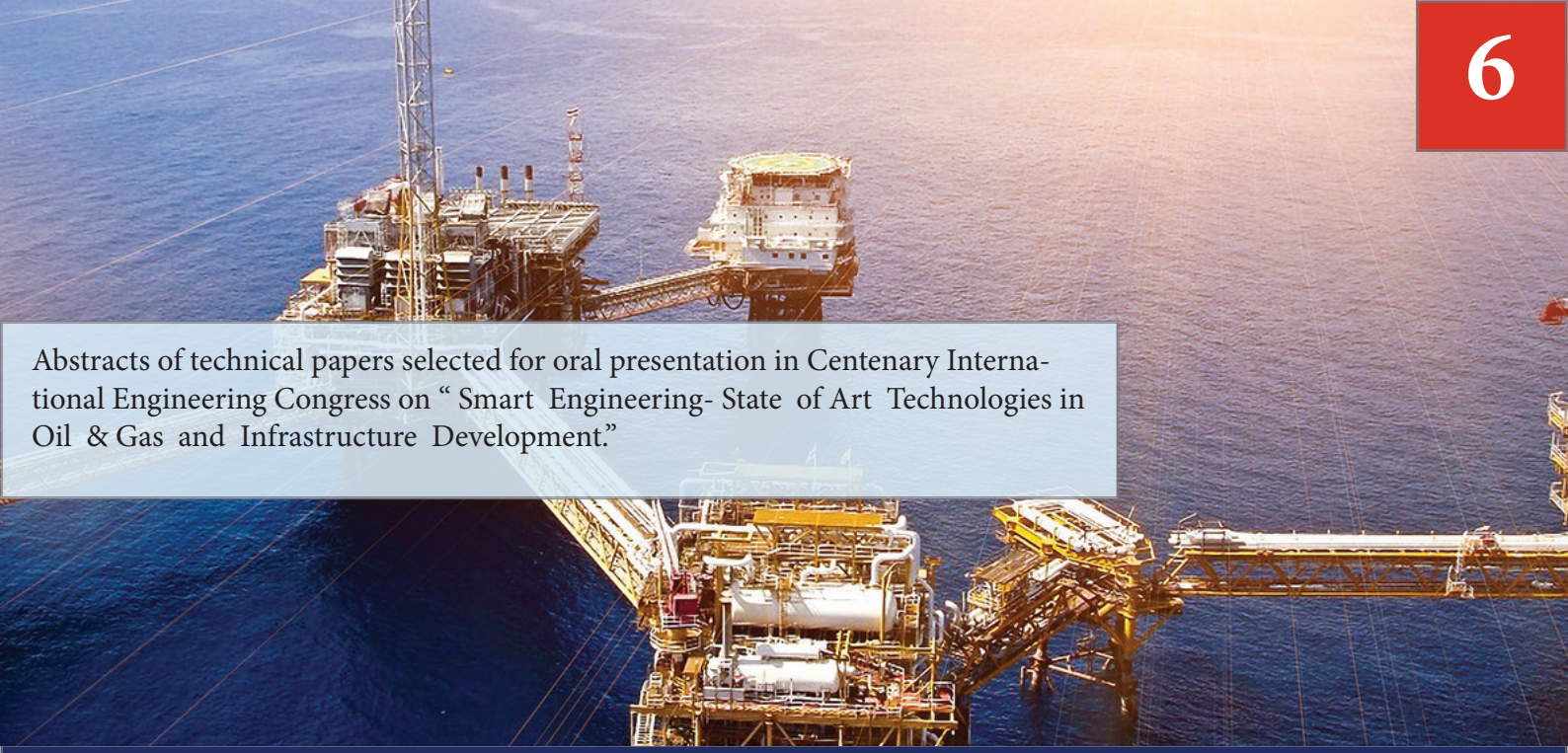


Conclusion

Ground improvement using stone column can be effectively used on loose sandy soils including silty or clayey sands having suitable bearing strata underneath. It is generally not suitable for sensitive clays and silts. Stone columns work most effectively when used for large loaded area. Their application in small groups below small isolated foundations is not typically done, since the whole area below the structure/ Equipment footprint and beyond to a certain extent needs to be treated, which negates the cost benefit. A geotechnical consultant's opinion should be sought on possibility of using stone column as an alternative to using pile foundations. There are a number of specialized companies who provide complete design and construction services for ground improvement using stone columns. In designing large foundations with primarily gravity loads and for mitigating liquefaction concerns, this option proves to be significantly cost effective when compared to pile foundations.

References

IS 15284 : Part 1- Design and construction for ground improvement - Guidelines: Part 1 Stone columns



Abstracts of technical papers selected for oral presentation in Centenary International Engineering Congress on " Smart Engineering- State of Art Technologies in Oil & Gas and Infrastructure Development."

Category I : State of Art Technologies in Oil & Gas industry

1- Paper ID: CIEC 13

The applicability of Personal Rapid Transit (PRT) in Oil & Gas and Infrastructure Development

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Abstract:

PRT is a state-of-the-art form of public transportation system that uses small automated electric pod-cars to provide a taxi-like service for individuals or small groups of travelers and to offer demand-responsive feeder and shuttle services connecting facilities, such as parking lots, with major transport terminals and other facilities including industrial zones. A PRT system has its own right of way with ecological benefits resulting from its low emission and low energy use. PRT systems are also associated with reductions in noise pollution and parking demands, while eliminating the requirement for manual operation. Passengers can ideally board a pod almost immediately upon arriving at a station and can take relatively direct routes to their destination without requiring to stop in between. Hence, the main advantage of PRT is its demand-responsive and short waiting time characteristics, which are especially relevant during off-peak hours. The majority of the PRT feasibility studies have been conducted for private developments, such as airports, mega shopping centers and ports, where the land acquisition cost was not an issue. In this study we will be investigating the applicability of such emerging types of public transportation systems connecting dispersed attraction centers in an oil and gas industrial zone. The outcomes from this study will develop a better understanding of the viability of implementing PRT systems for oil and gas zones where dispersed destinations with moderate demand are anticipated and where visual intrusion and land acquisition are not issues.

2- Paper ID: CIEC 14
Development of Nano-Catalysts for Low Temperature Methane Combustion

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Abstract:

In the recent years, natural gas has received an increasing attention as an attractive fuel. However, the release of unburnt methane into the atmosphere is a serious environmental issue since it is a strong greenhouse gas than carbon dioxide. The conventional thermal combustion of methane requires very high temperatures (up to 1600oC) and results in production of NOx as by-products. Thus, the development of effective methane combustion catalysts would have a significant impact on a number of energy-based technologies. CH4 combustion promoted by heterogeneous catalysts would not only utilize the energy of methane at lower operating temperature but would also increase system performance and limit NOx emissions by drastically reducing the required temperatures.
We report on the synthesis and testing of ROBUST nano-catalysts for low temperature methane oxidation. The nano-catalyst was palladium/ceria supported on alumina prepared via a one-step solution-combustion synthesis (SCS) method. Compared to the conventional catalysts, our novel nanocatalysts exhibited superior activity with no sign of deactivation in the temperature range between ~400 and 800oC.

Keywords: Pd-nanocatalyst, CeO2 effects, Oxygen vacancies.

3 - Paper ID : CIEC12
Impact of ISO17025 Accreditation of Engineering Labs on Smart Engineering

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Abstract

ISO/IEC 17025 is for use by laboratories in developing their management system for quality, administrative and technical operations. ISO17025 Accreditation of engineering labs is a systematic approach to control all processes carried out in the lab including its well defined procedures and supporting documentation. This will help in achieving the technical competence and gaining the confidence of users. It creates greater quality awareness amongst employees and reduces defects, scraps, rework , failures and service recovery.
This paper will highlight the mandatory steps required to achieve ISO 17025 accreditation, the process of maintaining and renewing the accreditation and will establish its impact on development and success of smart engineering.

Key words: ISO, Accreditation, Procedure, Competence, Confidence, and Impact

4- Paper ID: CIEC 16

Reaction kinetics of Carbon Dioxide with aqueous Potassium Salts of Amino Acids in N-Methyldiethanolamine and Diethanolamine blends using stopped flow technique

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Abstract.

Amine-based CO2 Absorption technology is considered to be one of the most mature process for capturing CO2 especially from large point sources. However, their drawbacks such as high enthalpy of the reaction and thermal and oxidative degradation, in addition to its corrosion tendency have led to the need of developing new amine systems with better CO2 capture properties. The use of aqueous salts of amino acids to promote the reaction rate of chemical solvents used in carbon dioxide absorption has been suggested by number of researchers. The aqueous salts of amino acids (AAS) are environmentally benign, less volatile and resistive to oxidative degradation. Since, analysis of kinetics of reaction of CO2 with the amine is a key factor in the development of new solvent for CO2 capture. In this presentation, the study of absorption kinetics of carbon dioxide (CO2) into two blends of N-Methyldiethanolamine; one promoted by potassium salts of taurine and the other by potassium salts of glycine along with a blend of DEA with potassium salts of glycine using the stopped flow technique has been reported. The obtained kinetic results shows that the both blends of MDEA and DEA with potassium salts of amino acids reacts faster with CO2 compared to the other conventional amine systems. Thus, justifying the use of both potassium salts of taurine and glycine as a promotor that can significantly enhance the reactivity of MDEA and DEA towards CO2.
Keywords: Carbon dioxide, MDEA, DEA, Amino Acids Salts, Kinetics, Stopped flow technique.

5- Paper ID: CIEC 17

Carbon Capture Through Mineral Carbonation of Steel-Making Waste

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b-Department of Chemical Engineering, College of Engineering, Qatar University

Abstract:

Mineral carbonation (MC) is evolving as a possible candidate to sequester CO2 from medium-sized emissions point sources. Electric arc furnace (EAF) bag house dust (BHD) exhibits sufficient alkaline properties since it is enriched with calcium compounds, namely, calcium oxides. In this study, accelerated carbonation of EAF BHD in reject brine has been evaluated in a novel reactor system, especially designed for contacting gases and liquids. The system consists of a vertical vessel with gas and liquid ports and inert particles. The inert particles provide circular motion which enhance the mixing process without compromising the operational aspects of the system. A factorial study was conducted on EAF BHD with the purpose of thoroughly classifying the discrete and combined effects of the operating parameters (steel dust concentration, CO2 gas flow rate and inert particles fraction) on the CO2 uptake by direct aqueous carbonation in brine. The analysis of the experimental results indicated that the optimum CO2 uptake was 0.22 g CO2/g dust. The best CO2 uptake performance (0.977 gCO2/g dust) was achieved at ambient temperature and pressure of 5 bar.

Category II : State of Art Technologies in Infrastructure Development.

1- Paper ID : CIEC10

Soil improvement through Vibro-Stone Column Technique – A case Study

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Abstract:

The Type of subsoil present at project site has a significant impact on the project cost. In cases where soil is very weak or susceptible to liquefaction the most obvious solution is to go for deep foundations with Piles, and embed them deep till load bearing strata is found. The choice of pile foundations typically leads to increase cost over open foundations and also impacts the schedule. However with research and development in the field of geotechnical engineering there are multiple ground improvement solutions available as cost effective alternatives to the pile foundation system. Ground improvement using stone columns installed using Vibro replacement/displacement techniques proves to be a very cost effective option.
A case study of foundation for large storage tanks is included in this paper. The storage tanks made of steel plates are supported on shallow foundation having ground improvement using stone columns employed. Comparison of cost for pile foundation system and foundation for stone column is also presented for this particular case. Various installation techniques, required in-situ tests, general comparison with pile foundation and design concepts are also discussed

2- Paper ID : CIEC01

Nation building using Performance-Based Durability Design of Marine Infrastructure for 120 years

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Abstract:

This article proposes the methodology for durability design of marine reinforced concrete infrastructures which suffers reduced life due to steel reinforcement corrosion. A change of design approach is recommended, from the conventional "prescriptive/deemed-to-satisfy approach" practiced by current design standards to a "performance-based approach" which considers the actual ageing process through probabilistic treatment. A full-probabilistic model-based durability design is performed on the achieved performance against the chloride ingress, serving as basis for a "major" maintenance free life. Using the model for chloride ingress and specified durability limit state, the design parameters are evaluated in terms of service-life of 120 years and target reliability level. During the course of 120 years, rise in temperature due to global warming will be significant, which accelerates corrosion. In this paper global warming is incorporated in the performance design. The design is demonstrated using a case study of a marine quay wall of a typical harbor. This article is based on the authors experience in providing durability design for infrastructures.

3- Paper ID: CIEC03

A new methodology in identification of Risk in Engineering phase of Fast-track project

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Abstract:

Each project is unique and execution of Fast-track project within the time and budget is quite challenging. The fast-track project possesses various phase which envelope various identical and dissimilar system / package. Each phase in fast-track project are concurrent with other phase. The challenge commences from Engineering phase in each fast-track project which are termed as Risk. Engineering phase is pivotal point that leads downstream phase in the project. It is necessary to identify and assess Risk from inception of the project till handover. The risk involved in Engineering process are inherent in each project due to design complexity, team communication, experience of team member, geographical location etc. In this paper, a new methodology has been proposed to identify the risk by breaking down the Engineering process based on the scope of a project. Concurrently, this break-down methodology supports Planning of the activities along with risk identification. Risk identification should to be precise such that Risk assessment and its mitigation plan should support the project to meet project objective rather than being an ornamental.
Keyword: Fast-track project; Engineering phase; Engineering process break-down; Risk identification; Risk assessment & mitigation plan; meeting project objective.

4- Paper ID: CIEC05
Oil & Gas and Infrastructure Development. Technological and conceptional development in organic matter characterization

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Abstract:
Today most of the countries in the world are importers of energy. The fossil fuels, accumulated over aeons of geological activity are irreversibly consumed at a rate more than million times faster than they were formed. This has left us in a precarious position especially for petroleum and its products. The hike in price of petroleum and its products, both in national and international scenes is frequent for two simple reasons; the mounting demands and fast depletion of reserves. The importance of petroleum in present day civilization is ever increasing due to its unmatched contribution for our energy requirements, in lubrication and in petrochemical field. Thus its competence to serve mankind is unquestionable and unique too. Sixty percent of the energy needs of the world are met by petroleum. The advent of I.C. and Jet engines have revolutionalised the techniques of motive power, a fact, without which rumbling civilization would have to contend with a snails-space. Such a premium stock of limited resources is fast depleting, perhaps due to indiscriminate and wanton consumption. The important question today is how long can the reserves meet the demand even with sky high prices? The high degree of conservation and restrictions in consumption may draw out the global reserves to another century at the consumption rate of today. According to Mayer and Hocott" There is no dearth of petroleum and natural gas resource remaining in the earth. As a matter of fact, there is no foreseen shortage of available supplies by present technology until well into the next century". Of course, every effort is made to locate new prospective fields, and innovation in search of secondary recovery techniques to lift the oils from existing sources, and what are presently uneconomical field, is in progress. The controversies may be subdued by understanding the formation of petroleum, at least to some extent. Perhaps resources may not be the problem, but availability may be.

5- Paper ID : CIEC08
Torsional Behavior of Artificially Degraded Steel I Section Externally Bonded with GFRP, BFRP & CFRP

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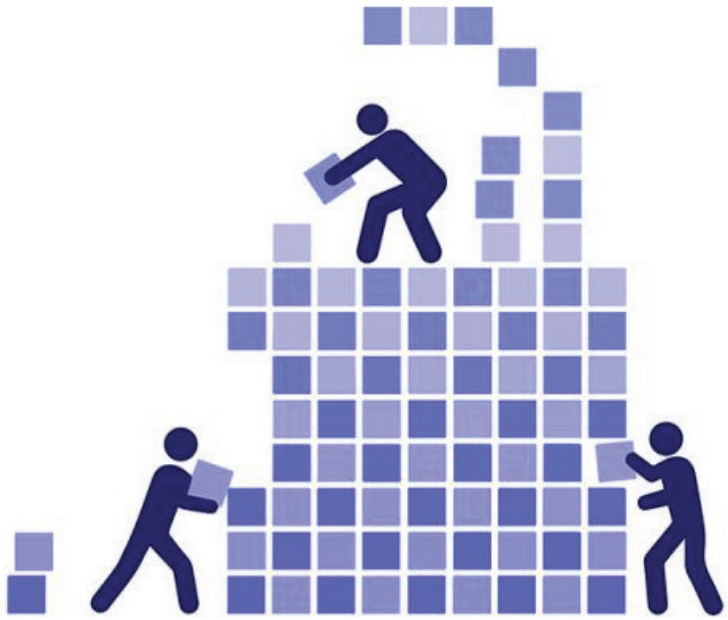
Abstract:
The oil and gas industry is highly demanding when it comes to the application of structural steel. Steel beams and girders are commonly used steel sections in the oil and gas industry. The main reasons of deterioration of these structural steel members are corrosion and ageing. Welding of additional steel plate is conventional strengthening method for these deteriorated steel members. Welding of additional plate increase the dead load and also susceptible for corrosion. These additional plates are huge, heavy; required heavy equipment's to fix it. Due to these disadvantages there is necessity to find alternative for repairing and strengthening of steel structures. Strengthening of steel structures by using FRP (Fiber Reinforced Polymer) is appearing to be excellent solution for these disadvantages. FRP offers advantages such as high strength-to-weight ratio, effortlessness drilling and anchoring, high corrosion resistance and high resistance to chemical attacks. FRP laminates formed via the wet lay-up process due to which FRP laminates follows the curve and irregular surfaces of parent structure. The main aim of this paper is to study the torsional behavior of artificially degraded steel I section externally bonded with Glass fiber polymer sheet, Basalt fiber polymer sheet, and Carbon fiber polymer sheet.
Keywords –Torsion; Steel; FRP; GFRP; BFRP; CFRP



CYBER PHYSICAL SYSTEMS SECURITY

BUILDING IN SECURITY

6 - Paper ID: CIEC 15
Cyber physical systems and internet of things security

1Dr. Devrim Unal & 2Dr. Noora Fetais
1Research Assistant Professor, College of Engineering, Qatar University
2Director of KINDI Computing Research Center College of Engineering, Qatar University

Abstract:

In this talk Dr. Unal will discuss security issues of Cyber-Physical Systems in general, and will also address more specific topics like cyber security of IoT, electricity grid, cars, Industry 4.0 and drones. The speaker has been in the information security and cyber security fields for more than 20 years with industrial, government and academic experience. Dr. Unal is now an Assistant Research Professor in KINDI Center for Computing Research in Qatar University.

Ref: TECH/CIEC-2019/CIEC05
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Submission of Full length Paper for Centenary International Engineering Congress on Smart Engineering- State of Art Tchnologies in Oil & Gas and Infrastructure Development.

Introduction:

Today most of the countries in the world are importers of energy.The fossil fuels, accumulated over aeons of geological activity are irreversibly consumed at a rate more than million times faster than they were formed. This has left us in a precarious position especially for petroleum and its products. The hike in price of petroleum and its products, both in national and international scenes is frequent for two simple reasons; the mounting demands and fast depletion of reserves. The importance of petroleum in present day civilization is ever increasing due to its unmatched contribution for our energy requirements, in lubrication and in petrochemical field.Thus its competence to serve mankind is unquestionable and unique too..Sixty percent of the energy needs of the world are met by petroleum.The advent of I.C. and Jet engines have revolutionalised the techniques of motive power,a fact,without which rumbling civilization would have to contend with a snails-space. Such a premium stock of limited resources is fast depleting,perhaps due to indiscriminate and wanton consumption. The important question today is how long can the reserves meet the demand even with sky high prices? The high degree of conservation and restrictions in consumption may draw out the global reserves to another century at the consumption rate of today. According to Mayer and Hocott"There is no dearth of petroleum and natural gas resource remaining in the earth. As a matter of fact, there is no foreseen shortage of available supplies by present technology until well into the next century". Of course,every effort is made to locate new prospective fields,and innovation in search of secondary recovery techniques to lift the oils from existing sources, and what are presently uneconomical field, is in progress. The controversies may be subdued by understanding the formation of petroleum, at least to some extent. Perhaps resources may not be the problem,but availability may be.

1)Title of the Project : Oil & Gas and Infrastructure Development.
2)Technological and conceptional development in organic matter characterization:

i)	Molecular separations,- Gas-liquid	Discovery of porphyrin pigments	Free base and metal-complex
	chromatography	in organic matter	porphyrin were demonstrated
			to be degradation products of
			chlorophyl from green plants.
			This confirmed the between
			biological molecules in living
			matter and compounds found in
			petroleum.
ii)	Petrology and Vitrinite	To chracterize organic matter	The coal petrology witnessed
	Reflectance	and thermal maturity	conceptual advancement along
			with its technical progress.The
			Vitrinite reflectance measured
			in standard conditions became
			standard practice for thermal
			maturity.
iii)	Optical techniques	To identify and characterize	Optically active compounds in
		optically active compounds of	petroleum fractions confirm the
		biological origin.	organic (biological) origin of

Iv	Mass Spectrometry.v)Carbon Isotopic Analysis.vi)Gas chromatography coupled with mass spectrometry(GS,GC-MS),vii) Biological Markers,viii) Pyrolysis Technique(Rock Evals),ix)Hydrous Pyrolysis,x)Microprocessor based analytical instrumentation,kinetic of kerogen transformation.,xi) Improved and sensitive analytical instruments like GC-MS-MS, pyrolysis-GC,Pyrolysis-Thermal-Evaporator-MS Analyser and ICP multicollector mass-spectrometer, Multi-temperature programming Rock-Eval-VI	To Characterise n-paraffin distribution in erude oils and sediment extracts .v)To characterize the origin of OM in rocks and oils,specially bacterial(biogenic) or thermogenic.vi)Separation, identification,determination and distribution of organic compounds in oils and sediment extracts.vii) Correlation of oil to oil and oil to source. Understanding the depositional environment and type of source input.viii) Kerogen characterization,quality of OM in source rocks.ix) To stimulate the thermal maturation of an immature kerogen or source rock.,x)Emergence of concept of Petroleum System.xi) Better understanding of nature of petroleum and its precursor organic matter at molecular level.	petroleum. Mass Spectrometic analysis of high molecular weight hydrocarbons in which mass spectral data was corrected to a monoisotopic basis for carbon and hydrogen leading to Characterization of n-paraffin distribution in erude oils and sediment extracts.v) The development in mass spectrometric techniques led to carbon isotopic studies applied to petroleum and sedimentary organic matter. Vi)GC involves a sample being vaporized and injected onto the head of the chromatographic column.The sample is transported through the column by the flow of inert,gaseous mobile phase.The ccolumn contains a liquid stationary phase adsorbed onto the surface of an ineret solid. GC coupled with mass-spectrometry(GC-MS) is a powerful analytical technique.vii) Development of biomarker concept led to comparision of structurally similar compounds in oils and sediment extracts with their probable precursor in living organisms.viii) Rock Evals, a standardized Pyrolysis method for source rock characterization, became a principle analytical tool in petroleum geochemistry.ix)Hydrous Pyrolysis is undertaken in a high pressure vessel in the presence of water.x)The development in sophiscated microprocessor based analytical instrumentation and better understanding of molecular and isotopic level compositions of petroleum precursor and petroleum.xi) Molecular level characterization of complex mixture of compounds found in petroleum and their genetic corrllation with precursor organic molecules from once living organisms.

3)Oil: At present production of oil in the world is about 3300MMta and gas over one trillion cubic meters. Fears of impending oil shortage have raised hopes of finding huge deposits of oil even under deep oceans.The activity now-a-days is more confined to such areas. According to Klemme there are 334 giant fields in 66 basins that contains 70-75% of oil.Indian subcontinent is placed in Type 4 basin(India and Assam) and the coastal belt in pulled apart basins.

Estimated sedimentary rocks of the world, by D.Ion and Hendricks is about 62X 10 to the power 17 tons, which contain an organic matter of 3.5X10 to the power 15 tons which in turn can yield a hydrocarbons content of 7.7x 10 to the power 13 tons.

Oil Shale: Oil shale is an inorganic rock that contains a solid organic compound known as kerogen.The term 'oil shale' is a misnomer because kerogen is not crude oil and rock holding the kerogen often is not even shale.Conventional liquid crude oil is organic material-plant and animal remains-exposed to heat and pressure in the absence of oxygen over millions of years within the earth. Kerogen is among the first stages in the process of petroleum generation from organic matter; bitumen- the hydrocarbon targated in oil sands projects-is formed from kerogen and represents a latter stage in the process. Kerogen to oil is done by retorting. To generate liquid oil synthetically from oil shale ,the kergen –rich rock is heated to 500 degree Celsius in the absence of oxygen, a process known as retorting. Shale can be heated under-ground known as in situ retorting or can be mined like coal and retorted on the surface. There are several competing technologies for producing oil shale.Exxon has developed a process for creating underground fractures in oil shale,filling it with a material that conducts electricity and then supplying power through the shale to heat it. Because of heat the kerogen,gradually converts into recoverable oil.Shell uses electric heaters that it buries underground to heat the kerogen slowly. Although estimates of the cost to produce oil shale very widely,it is more expensive and energy-intensive and is economical if oil price goes higher than S100 a barrel and feasible for production.

4)Gas : Gas from petroleum is classified under several names like natural gas,associated gas, dissolved gas, casing head gas and offgas from refinery.

a)Natural Gas: Its name indicates it is readily available in nature, almost as a finished product. It contains mainly varying proportions of methane. It may be accompanied by other dry gas fractions like ethane and propane to a small extent. In addition to these combustibles some inert gas like CO2,N2, noble gases are also present. The proportion of methane ranges from 85% and goes upto 98%

b) Associated Gas: This obtained from oil reservoirs and this exsists as a separate gas cap over liquid phase. Though the gas mainly consists of methane and to some extent ethane and propane, the proportions vary depending upon the reservoir conditios. When the gas phase is taken out, it may still contain some liquid hydrocarbons mainly of volatile range like butane and pentane, which when condensed are termed as natural gas liquids.

c) Dissolved Gas: Gas may be present in the liquid hydrocarbons mainly in the dissolved state depending upon the formation pressure. When the pressure is decreased, this dissolved gas comes out of the oil. Gas production upto 10% crude produced is not uncommon with the oil reservoirs. It is fair to strip off such dissolved gas before crude is transported to long distances by means of pipelines or tankers. The remaining dissolved gas is first to come out of the distillation column because of higher temperature than the surroundings.

d) Casing Head Gas: Gas that has escaped through oil well Christmas trees is termed as casing head gas.It is also more or less similar to natural gas but contains less % of methane and high percentage of ethane and propane than natural gas. It is a by-product of oil production.

e) Refinery off Gas: In arefinery,gas is formed in cracking and reforming operations due to the thermal degradation of liquid hydrocarbons. During stabilization of wild gasolines or processed gasolines.the gases are vested. Thus the gas is mainly a mixture of saturates and unsaturates and quantity is also not assessable. This forms a major source of heat energy for refinery, as well as feed stock for petrochemicals. In fact, without any exclusion, all these gases can be utilized for petrochemical industries. All the gases contain impurities like CO2,N2, mercaptans,H2S,water vapour, suspended impurities etc. First three paraffins are gases at room temperature. Mixture of methane and ethane is called wet gas.Where petrochemical industries are not instituted, dry gas would find its use mainly in the refinery fuel system. Wet gas is usually liquefied and sold for commercial purposes. Butane is diverted to gasoline streams as a blending component,as butane has more commercial value when blended with gasoline.

f) Liquefied Petroleum Gas(LPG): The gas that is vented from refinery distillation units, is processed and conveniently stored after liquefaction.For do-

mestic heating purposes, it is supplied in small cylinders, while for industries tanker supplies are called in. This gas is known as liquefield petroleum gas as it is stored in vapour liquid mixture. Ease of handling, smokelessness,good and steady heating rates are some key points, that made this fuel a popular kitchen aid to the housewife of modern times. Rising demands of this fuel in domestic and industrial circles are met by the refinery by installing processing units.

Distillation of Petroleum: Distillation is a separation technique used for separation of soluable liquid mixture into individual components. Petroleum being a mixture of hydrocarbons has a boiling range of -160 Degree Centigrade (methane) to + 1000Degree Centigrade or more(pitch) i.e. to say a mixture of gas ,liquid and solid, requires an effective and economic distillation to process into a number of cuts of small boiling range. These cuts are later processed and tailored to suit the requirements of consumers. Modern refinery techniques have meticulously laid the way to recover as many fractions as possible from crude,-discarding the least possible in view of the binding situation i.e. dearness of crude. The basis of refinery distillation design rest completely on TBP tests.
Distillation of crude mainly takes place in two stages. First stage distillation is carried out at atmospheric pressure,hence the name 'Atmospheric Distillation unit (ADU)is conferred on it. The undistilled portion of crude,called reduced crude is further distilled under reduced pressure in a second unit known as'Vacuum distillation unit. The maximum pressure in in an atmospheric column seldom reaches two atmospheres and at the top of the column the pressure is only few centimeters of mercury above atmospheric pressure.These two columns differ from conventional towere in practice in a peculiar and conspicuous way by not providing any reboiler.
This has been overcome by heating the feed to maximum permissible temperature only once and allowing it to flash in towers. The maximum temperature allowed in topping operations is 375Degree Centigrade. Higher temperatures are not permitted due to degradation of crude by thermal cracking. When the crude contains a good amount of soluble gases, to avoid load on ADU, a preflashing or topping column is employed.Preflashing is also useful when crude has to be transported to a long distance. Light-ends-free crude gives no problem in transportation.A crude containing less than 6% light ends(gases) usually offers no problem in transportation. Preflasing is conducted at 100Degee Centregrade under a pressure of 3-5 atmosphers to remove these light ends.
Design of atmospheric column is based upon experience,intuition and emphericism. Because of the unpredictable nature of crude,this type of design has been developed.Crude, even though it contains innumerable components,they fall into small close boiling cutsand so individual separation is not possible; hence the design is significantly based upon the TBP and EFV data.Modern towers operate with remarkable accuracy and match with any critically designed tower. Adoptability of resembling crudes and marginal adjustments in quality of cuts are some of the flexibilities of these towers.Further, control by conditions and quality of reflux, along with other operational parameters contribute much towards desired product pattern.

5) Important Tests:
Test for Gasoline:The important tests prescribed for gasolines are:
ASTM distillation
Reid vapour pressure
Octane number
Gum content
Sulfur content etc.

Conclusion :

Energy consumption in the developed countries may increase by 3-3.5% a year while developing economies like China, Brazil, India,Turkey may reach unexpected consumption rates.China's strategy of tapping in and around may produces 70% of its oil demands by 2035 while looking for another 150 MMTPA. Brazil with 4 or more million tons of alcohol can go for cleaner energy. Its inorganic oil fields along with one of the biggest discoveries in the world can export 100MTPA by 2035. India on the other hand is ina deplorable condition. No Systematic policies to find alternative energy sources have been implemented, Solar panels/solar vehicles should have been the order of the day, but no hope even for another ten years. Stunning growth in automobile sector would drain of continuously exchange reserves, making the country more dependent on oil from other countries. Even nuclear energy is not progressing, facing hurdles due to local resistance hence energy sector's future is dim. Aided by no strict policy on growth of population as followed in China, India's population will grow at much faster rate than any other country adding more perils to energy sector. Royal Dutch Shell, when major oil resources getting harder to find, and the need for cleaner,reliable alternative energies to share growing needs of population Shell's slogan for 250 year supply of NG to the World is well known, however the effect of it in Market price is not good.

Thanks & Regards,
Dated: 08.09.2019
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Declaration Form